MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

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(Paraphrase of statements in an address by Dr. R. A. Millikan at A.S.M.E. San Francisco Meeting)

AUGUST 1926

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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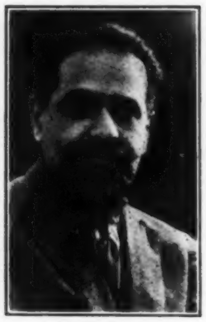
L. D. Burlingame



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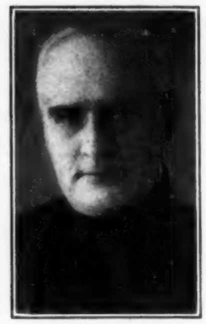

W. H. Tschappat

Contributors to this Issue

J. A. Mathews, vice-president of the Crucible Steel Co. of America, is a graduate of Washington and Jefferson College with the degrees of B.S., M.S., and Sc.D. He has received the degrees of A.M. and Ph.D. from Columbia and has taken post-graduate work in the Royal School of Mines, London. He was assistant manager of the Sanderson Works of the Crucible Steel Co. from 1902 to 1908, general manager of the Halcomb Steel Co., from 1908 to 1915, and president of that company from 1915 to 1920. He gave up executive work to resume his scientific work as metallurgist and director of research development as vice-president of the Crucible Steel Co. of America.

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A. I. Lipetz, consulting engineer with the American Locomotive Company, Schenectady, N. Y., was graduated from the Polytechnic Institute at Warsaw with the degree of M.E. and later passed examinations for professorship in applied mechanics at the Polytechnic Institute of Kiev, of which he was assistant professor. For three and a half years he was chief of the locomotive department of the Tashkent Railway, Russia, and later held the positions of chief of the locomotive department of the Russian Ministry of Ways of Communications and of assistant professor of the Institute of Engineers of Ways of Communication, Petrograd. In 1915 and 1916 he was sent to the United States as representative of the Russian Railway Administration and then became chief of the Russian Mission of Ways of Communications in the United States. In 1920 he joined the American Locomotive Company representing the sales and engineering department in Europe for several years.

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J. K. Wood, a consulting engineer on spring design and engineering materials, has been engaged as a mechanical engineer by the Westinghouse Electric & Manufacturing Co. in connection with the design of electric locomotives; and by the Western Electric Company, Inc., in connection with the use of materials and springs in the design of automatic telephone equipment.

H. H. Dow, president and general manager of the Dow Chemical Co., Midland, Mich., was graduated from the Case School of Applied Science in 1888 and in 1924 received the honorary degree of Doctor of Engineering from the same institution. Since 1889 he has been a manufacturer of chemicals as partner or officer of the Midland Chemical Co., Inc., the Dow Process Co., and the Dow Chemical Co.

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W. H. Tschappat was graduated from the U. S. Military Academy in 1896 and commissioned in the Artillery. He was transferred to the Ordnance Department in 1898 after the Spanish War. He then served at various arsenals including the Army Powder Factory at Picatiny Arsenal, Dover, N. J., and the Army Proving Ground, Sandy Hook. From 1912 to 1917 he was professor of ordinance and gunnery at the U. S. Military Academy. From 1922 to 1925 he was in command of the Averdeen Proving Ground.

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A. B. Newell worked through the earlier developments of the type of engine in various capacities and for a number of firms until 1916, when he made a Diesel installation for the San Juan Fishing and Packing Co. of Seattle, and operated it a few months. In 1917 he became chief engineer of the M. S. *Alabama.* He sailed as chief engineer of the M. S. *Challamba* from 1919 to 1920, then joined the M. S. *Bramell Point* of the Vacuum Oil Fleet, of which he was chief engineer until 1923, at which time he became guarantee engineer of the New York Shipbuilding Corp.

L. D. Burlingame has been since 1914 industrial superintendent and patent specialist for the Brown & Sharpe Manufacturing Co., Providence, R. I., with which firm he has been associated for forty years. He is a member of the National Screw Thread Commission and chairman of the joint committee of the A.S.M.E. and S.A.E. on Standardization and Unification of Screw Threads.

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E. R. Hedrick, professor of mathematics at the University of California since 1924, was educated at Michigan, Harvard, Goettingen, Germany, and the École Normale Superieure, Paris. Following this he was an instructor in Yale Sheffield Scientific School and later, from 1903 to 1904, was professor of mathematics at the University of Missouri.

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S. W. Miller is consulting engineer with the Union Carbide and Carbon Laboratories, Long Island City, N. Y. He is a graduate of Stevens Institute of Technology, '87, and during his career has been connected with the Pennsylvania Lines, the American Locomotive Co., and the Rochester Welding Works.

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W. E. Wickenden has been since 1922 director of investigations of the Society for the Promotion of Engineering Education. During his career he has been connected with the University of Wisconsin, Massachusetts Institute of Technology, Western Electric Co., and the American Telephone & Telegraph Co.

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B. L. Newkirk was graduated from the University of Minnesota in 1897. He received his A.M. in 1899 and his Ph.D. from the University of Munich in 1902. From 1907 to 1920 he served as assistant professor of mathematics and mechanics in the University of Minnesota. Since then he has been connected with the Research Laboratory of the General Electric Co.

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H. P. Cox, Jr. is a 1925 graduate of Rensselaer Polytechnic Institute. He is now with the Hevi Duty Electric Co. in Milwaukee.

H. P. Cox, Jr.

E. R. Hedrick

B. L. Newkirk

MECHANICAL ENGINEERING

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Present Tendencies in Engineering Materials

By JOHN A. MATHEWS,[1] NEW YORK, N. Y.

WHEN I began the study of qualitative analysis a great many years ago—thirty-five to be exact—we used a little red-covered textbook by Eliot and Storer. It was not until a few years ago that I discovered that one of the authors was no other than the great educator and philosopher, he of the five-foot book shelf—Dr. Charles W. Eliot, of Cambridge. He was president of Harvard when I was a student, but it never occurred to me that Eliot of Harvard might have been at one time a teacher of chemistry. It was a satisfaction to me to learn that in this respect our early years were similarly spent.

Recently Dr. Eliot gave expression to a thought I had long been cherishing as a private opinion, when he said, "It is obvious that standardization has become a dangerous adversary of progress in both education and industry." This idea must have been more widespread than either of us knew, for some five years ago a writer of verse for one of the comic papers dealt with it at great length and I will only quote a few of his stanzas to illustrate his understanding of "A Standardized Existence:"

A visitor at large, I stand
Beneath a standard sky—
Where everything is standardized
To please the standard eye.

Each tree is of a standard height,
Each building is the same;
Each man is uniform in height,
And has a standard name.

Above there is a standard star
Beside a standard cloud,
And standard weather here prevails
To please a standard crowd.

With standard joy, and standard gain,
The standard people live;
And if there is one bit of pain,
'Tis such as standards give.

I will spare you the rest, but those verses were given to me in 1920, by Mr. A. A. Stevenson, a dyed-in-the-wool Standard Bearer!

Seriously, I think we may accept Dr. Eliot's words if not as quite literally true, yet at least as containing a sufficient germ of truth to cause us to pause and seriously reflect.

Specifications—What They Should Embody

We sometimes refer to production in plants in terms of "man-hours." I hate to think of the man-hours spent in the last twenty-five years arguing, haggling, disputing, and compromising over so-called standard specifications. Being compromises they are rarely wholly satisfactory to either producer or user, and they rarely represent the highest-class material. They may be misleading to the small manufacturer who has no highly skilled technical staff, but who assumes that they represent the last word in raw materials. It may be his requirements call for the very best, and that by the use of existing specifications he is led into serious trouble and expense.

The big manufacturer with a technical staff frequently ignores them or uses them as a basis for building up his own more stringent specifications, often of the type the late Dr. C. B. Dudley referred to as affording "an occasion to show how much we know." They are so very special that no general stock material will meet them, and they call for special manufacture and hence are no longer "standard."

Perhaps my slant on this subject is a bit peculiar, but as a manufacturer interested in the highest qualities and very special products I dislike intensely manufacturing *down* to a specification rather than *up* to an ideal, in order to meet competition and to remain in business.

Twenty years ago engineering steels were usually bought on the basis of mechanical tests; more rarely they were bought to chemical analysis, and he who sought to specify both had a fight on his hands. Now, not only mechanical properties and analysis are commonly combined, but a lot of new tests are added, and to conclude a paragraph something like this is found:

> The steel shall be free from seams, pipe, slivers, segregation, inclusions, dirt, decarbonization, etc., etc.

One of our customers has shortened this formula by writing on the bottom of each order: "This must be perfect steel," which is no more extreme than the more formal statement. No one has made, or is likely to make, steel that cannot be rejected (particularly on a falling market or a long inventory) under either form of expression. Furthermore the defects enumerated are not capable of exact statement or determination. They must always be mere matters of opinion and hence of dispute, and since perfection in steel making does not exist it becomes a question of what number or amount, or in what degree of aggravation, the alleged defects may exist in good commercial practice.

Speaking upon the extravagant claims of the early electric-furnace inventors, Sir Robert Hadfield once said: "Unfortunately they assume that all steel as now made is fundamentally wrong." That seems to be the attitude of some inspectors, who seem more interested in finding a technical failure to meet the specification than they are in knowing whether the material will, as a matter of fact, answer the purposes for which it was purchased. So aggravated is this condition that as the result of long observation and investigation among other manufacturers I once said: "A very large percentage of the steel complained of, or rejected upon inspection, is objected to for the reason that it does not conform to some arbitrary set of chemical limits, or to some new, little understood physical test, rather than because the inspector knows definitely that the steel is unsuited to the purpose for which it was bought." I may go further and say that usually not an iota of proof is offered that it is not.

Now, how has this come about? In my judgment industry has become "scientific" faster than science has been able to assimilate experience. The empirical methods of generations of steel-making practice were not totally unscientific. The recent graduate metallurgist knows a lot *about* steel but he doesn't *know* steel, and is often illogical in correlating cause and effect. Nowhere is this more apparent than in the interpretation of macro and micro etchings. Laboratory tests are substituted for practical tests and experience. Science should be an aid to all industry and a detriment to none. We must not become so technical that we cease to be practical.

A fond father, interested in the proper instruction of his son, took him for a walk in the fields one day, and seeing a flock of sheep, said:

"My son, if I should call that lamb's tail a leg, how many legs would it have?"

"Five," promptly replied the son.

"No," said the father, "my calling it a leg wouldn't make it one."

[1] Vice-President, Crucible Steel Company of America.

Address delivered at a dinner of the Engineering Foundation, New York, May 17, 1926.

High-power metallography has permitted us to recognize and name a lot of structures in steel, but naming them doesn't make them different from what they always were, even before we saw them. That we can see them at all is because steel is a heterogeneous substance and not a homogeneous one, and this is because of certain chemical laws governing the freezing of solutions, laws of mass action, surface tension, etc. The laws of nature are the laws of God, and they are not subject to amendment or recall. The heterogeneity of steel is not due to the innate "cussedness" of the steelmaker, as seems to be frequently assumed. It seems to be easy to ascribe failures to things that look a million times larger than they really are as seen by the microscope, and hot-acid etching for macroscopic examination has a way of greatly enlarging things that are exceedingly small in fact. Of microscopic examinations, as of nature, it may be said: "The difference between landscape and landscope is small, but there is a great difference in the beholders." There is no difficulty in "seeing things" in steel with a microscope; the trouble is in interpreting what we see.

On several occasions, and at the risk of being misunderstood, I have taken what is apparently the unpopular side on the question of use or misuse of standards, specifications, and inspection methods. I have no objections whatever to specifications that fill three requirements, namely, that they are an advantage to the maker, an advantage to the user, and are for the good of the public. Such specifications will be fair and reasonable, and their enforcement by inspection should be equally fair and reasonable. In this attitude I have taken comfort in the words of Emerson:

> If you would be a man, speak what you think today in words as hard as cannon balls, and tomorrow speak what tomorrow thinks in hard words again, though it contradict everything you said today. "Ah, then," exclaim the aged ladies, "you shall be sure to be misunderstood." Misunderstood! It is aright fool's word. Is it so bad then to be misunderstood? Pythogoras was misunderstood, and Socrates, and Jesus, and Luther, and Copernicus, and Galileo, and every pure and wise spirit that ever took flesh. To be great is to be misunderstood.

Good sense is highly desirable in writing specifications and is even more necessary in interpreting them. If they only contained the minimum number of requirements to define the character of material wanted, as the late Dr. C. B. Dudley urged many years ago, the matter would be greatly simplified. Rarely do they cover the only material suited to the purpose intended, and more rarely do they cover the best material for the purpose intended. Once written, they become as the laws of the Medes and Persians, which alter not. They acquire a sort of sanctity, like the Ten Commandments or the Constitution before the adoption of the Eighteenth Amendment.

The late Prof. Robert S. Woodward, returning from an academic function at Cambridge University, told me he had observed that "in England science is respected, but in America it is merely respectable." The American public seems to accept the results of scientific achievements in material things, but pays scant attention to science itself. In advertising language, we have not "sold" science to the public. Either for the most part our great men are unable to state scientific truths in readily understandable language, or else they feel it beneath their dignity to do so. In England the popular scientific lecture is seen at its best, and no man is so great that his dignity suffers by lecturing at the Royal Institution or the Society of Arts, or even by giving lectures to children during the Christmas holidays. Can you imagine our children thus spending their holidays?

The New York Electrical Society has been editorially commended for its efforts during the past winter to bring the newest knowledge of electricity to the public. The American Chemical Society has been carrying on a great program looking to the same end. Such efforts should be encouraged in every division of science, and the outcome will be for the intellectual and moral uplift as well as for the advancement of true religion when all the people "shall know the truth" and the truth shall make them free.

You might not suspect from what has gone before that I am serving my second term as a member of the Executive Committee of The American Society for Testing Materials, nor that I am an Honorary Member of the American Society for Steel Treating. However, it is the abuse and not the use of standards and specifications—the overzealousness in some directions—that I am discussing. In some aspects of the subject I am reminded of the colored preacher who invoked Divine assistance to know the unknowable, to see the unseen, and to unscrew the inscrutable.

The Ever-Widening Expanse of Engineering Requirements in Materials

It is debasing to a man to use his scientific attainments to help him shirk responsibility. Truth for truth's sake should be the aim of the industrial worker as well as of the academic worker in science or technology, and that is not the attitude of the manufacturer who always insists the trouble is with the user, or of the user who insists the trouble is always with the material. As Faraday said a century ago:

> The philosopher should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biased by appearances; have no favorite hypothesis; be of no school; and in doctrine have no master. He should not be a respecter of persons, but of things. Truth should be his primary subject. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of nature.

As has been said, the general run of engineering requirements were formerly met if we knew the analysis of the material or its physical properties—usually in the natural or annealed condition. The ever-widening expanse of engineering requirements outgrew that condition several years ago. Probably the automobile and the airplane did most to stimulate an interest in materials of superstrength and toughness. Even these requirements were but for stronger materials and did not present many really new problems. Resistance to shock and fatigue gradually received attention, and methods of testing these properties were devised and investigations made. To those dealing in the ordinary structural materials of, say, 50,000 to 75,000 lb. per sq. in. tensile strength, it may be interesting to know that certain steels used for gears, for example, are expected to show a minimum of 285,000 tensile, 260,000 elastic limit, together with fair ductility; for example, 7 per cent stretch in two inches and 20 per cent reduction in area. Such steels are by no means brittle but must show a reasonable resistance in the Izod shock test.

As compared with former practice this is merely a question of degree in the familiarly known mechanical properties. It may be of interest to mention that several physical properties that a few years ago were rarely mentioned are quite frequently of interest to the new engineering requirements. We may mention, for example, the coefficient of thermal expansion. Inquiries are frequent where expansion both lower or higher than that of normal steel is wanted. These are met by means of various alloy steels showing from nearly zero expansion up to an expansion 50 per cent greater than that of normal steel. There is also much interest in magnetic properties, both of the transient and permanent type; nor should we forget non-magnetic steels. It is possible to make non-magnetic alloys out of the magnetic elements and also magnetic alloys out of non-magnetic metals, and in some cases the same alloy may be either totally non-magnetic or very highly magnetic, according to the heat treatment given.

We were recently asked for a steel with a nearly zero elastic coefficient which would also be non-corrosive. We said we thought we could furnish it, but that the material would be non-magnetic. This wouldn't do at all; so you see not only one but several very unusual characteristics must occasionally be combined to make engineers happy.

Electrical resistance, reflecting power for light, and resistance to wear must be given attention. Permanence, as regards volume over long periods of time and freedom from spontaneous volume changes with time, is of interest for length standards, master gages, etc. The one who meets all these diverse needs of industry should be a physicist, but the man who makes the steel itself should have a physico-chemical training. Metallurgy is fast becoming a branch of physical chemistry and a very important one, but unfortunately that fact does not seem to be generally recognized. Unfortunately, too, it has not the background of established data and physical constants, and the acquiring of these fundamentals is well worth while and in this department of metallurgy America has not done its part. Our best physical metallurgists are in industries and not in universities, but if Mr. Hoover secures his $20,000,000 for pure-science research, I hope we shall soon find them there.

Recent Demands on the Steel Metallurgist

There are two other recent demands of engineering that deserve special attention. One of them has been quite fully met and the other is still to be met. I refer (1) to non-corrosive or stainless steels, and (2) to steels for use at high temperatures. These two properties are closely related, for we cannot go to very high temperatures without having to consider oxidation and other chemical attack by products of combustion, gases, and liquids. As regards atmospheric conditions and the effect of ordinary fruit acids, organic acids, alkalis, etc., we have a wide range of products, each one surprisingly good under certain special conditions but none a universal resistant to all kinds of corrosion. Hydrochloric acid and many of the chlorides are not successfully resisted by any ferrous alloy, but nitric and sulphuric acid, syrupy phosphoric acid, glacial acetic acid, and the general fatty or vegetable acids and products of decomposition are perfectly resisted, and in most cases when either hot or cold, weak or strong. Exact conditions of material and use must be known before the right material may be prescribed.

Dr. H. W. Gillette, Chief of the Metallurgical Division of the Bureau of Standards, recently said: "Power plants and turbine designers, valve manufacturers, builders of oil-cracking stills, chemists dealing with nitrogen fixation, furnace designers, and others are loudly calling for new materials to stand up under increasingly high temperatures, and for more accurate data on the properties of known materials at these temperatures."

Recognizing this need, The American Society of Mechanical Engineers and the American Society for Testing Materials held jointly two conferences, one in Cleveland and one in Atlantic City, two years ago. At these conferences the whole available information was reviewed, and later a joint research committee sponsored by the two societies was created because it was found how scanty and inadequate the data were. This joint committee finds that first of all it must devise methods of test which will permit of direct comparison of the work of different laboratories. Much of the existing data is of little engineering value because of the uncertain conditions under which the tests were made. The tensile work in the past has been of the nature of short-time tests in which the material was pulled as soon as more or less certain temperatures were reached. Later it appeared that metals have a tendency to flow or creep under continually applied loads that can be withstood readily for a short time. It then becomes necessary to attempt to correlate the short- and long-time tests, and this is being done, but the time consumed in the long-time tests, frequently of the order of a thousand hours or several months, means that no one or several laboratories will be able to provide any great mass of data upon which to base general laws or conclusions. Emmet's mercury boiler, Benson's boiler of 3200 lb. pressure, and even the more conservative types of boilers seeking higher temperatures and pressures, present problems that cannot be answered with certainty until some of this work is done. The gasoline supply cannot come from direct distillation as formerly but must be made by cracking methods, and these present similar problems. They are not simple problems of one variable, namely, temperature, but most of them include corrosion of many kinds, erosion, resistance to wear, relative expansion and electrolysis, besides the practical problems of fabricating, welding, riveting, etc., for the materials which give most promise of success are very different from the old materials of construction with which all engineers are familiar, and for which there are many handbook data and formulas, and wide-spread knowledge and familiarity. In the Henry M. Howe Memorial Lecture for 1925 I referred to the antiquity of much of this knowledge, characterized it as alpha-iron metallurgy, and stated:

> The public does not appreciate that there are many steel alloys which do not rust and, in fact, will resist many of the strongest acids. Many of these alloy steels are totally non-magnetic; they are greatly softened by quenching and are almost incapable of overheating short of fusion. They are not subject to heavy scaling and many of them will withstand 2000 deg. fahr. for a long period in an oxidizing atmosphere. Ordinary steel is embrittled at low temperatures, but some of these products become increasingly more resistant to shock as the temperature decreases, as shown by Langenberg's exhaustive investigations of temperatures as low as −80 deg. fahr. We have immersed some of these alloys in liquid air and after 15 min. refrigeration found them to flow readily under hammering and to stand a flat cold bend.
>
> This is not general knowledge; in fact, it is not widely known to steel metallurgists and engineers. It is gamma-iron metallurgy. The very great industrial usefulness of alloys possessing such remarkable properties seems to warrant some consideration of their physical properties and structures. Gamma-iron metallurgy is in the making. We shall know better how to use these steels when we understand their metallurgy and properties. They have had much attention in certain directions for almost a generation but they cannot be said to be generally understood or appreciated from an engineering point of view.

It would appear that gamma-iron metallurgy was alpha-iron metallurgy in reverse gear!

These are not new products either; they have been made and known for several years not only in America but in France, Germany, and England. It would appear that their production had, in fact, anticipated the engineering demand, for which fact I hope you engineers will give us metallurgists some credit.

The alloys upon which we must pin our hopes for the most extreme cases of high-temperature use, resistance to oxidation and corrosion, are rich in nickel and chromium, together with smaller but substantial additions of silicon, copper, tungsten or molybdenum, or several of them. It is not a single alloy but a group of alloys which demand attention, research, investigation, and exhaustive study of their physical properties, so as to determine the best alloy for each highly special application.

The joint research committee already referred to has a program of investigations laid out. It calls for $50,000 and the coöperation of many university and industrial men and laboratories. This sum would not begin to cover the cost were any large part of it to be paid for at all. The estimate has been very carefully made and is conservative, and if industry and engineering are as much interested in these subjects as we have been led to believe, the project is worthy of support. As a matter of fact, the joint committee is almost wholly composed of prospective users and not producers of these materials, the speaker being the only exception. These alloys are of the type known as austenitic. Ordinary steels are austenitic when heated above their critical temperatures, and a very sudden change in properties occurs at those temperatures. The fact that these steels are permanently austenitic probably accounts for the uniformity in many of their properties over such a wide range of temperatures as from liquid air to a bright red heat. Sudden breaks in many of their properties simply do not occur during their useful range of application.

These products have been and are being studied not only by American investigators but also in France, Germany, and England, but their introduction into industry has been slow owing to the necessarily high cost. Some day, however, it will be more apparent that parts which never require replacement are cheaper than those that do, when fabricating costs and loss of time and production are considered.

Applications of the Alloy Steels

A few successful applications may be of interest. We shall not mention such things as table cutlery, cooking utensils, and containers as these are well known, nor shall we go into details as to the specific types of alloys used in the examples to be mentioned.

Michael Faraday, generally thought of as a physicist, was possibly the first to make a wide series of alloy steels. One of his purposes was to make a steel suitable for metallic reflectors that would stay bright. He did not succeed, and one hundred years later I had the pleasure of furnishing Mt. Wilson Observatory a six-inch disk which, after hardening, was ground and polished to within one five-hundred thousandth of an inch of perfect flatness. There is no doubt but that it will meet all the requirements Faraday had in mind.

In this country and abroad these materials have been successfully used for dental plates and bridge work, replacing the precious metals. The plates do not tarnish nor discolor, and have no taste.

Periscope tubes and many submarine parts have been made of these materials, which in many cases have replaced non-ferrous alloys because of greater strength, higher modulus of elasticity, and satisfactory resistance to sea water.

A very interesting application is for power-transmission belts, made endless by cold-rolling strips with ends welded together.

They are said to be very efficient as compared with leather or fabric, besides being especially suitable for out-of-door use or in atmospheres polluted by acids as in pickling rooms. Very long continuous operation has been reported.

The Bureau of Mines made exhaustive tests of more than fifty ferrous and non-ferrous materials in three different mine waters for a protracted period. Of all the wrought materials austenitic steels showed up best, and in some cases were almost totally free from attack. Practical use in pump shafts before and since have confirmed these experimental results fully.

Among applications where high temperatures as well as corrosion and oxidation are concerned may be mentioned the generally successful use as turbine blading in steam turbines, and now we have recently seen reported similar results in the rotor of a gas engine working on exhaust gases. This rotor operated at from 1500 to 1650 deg. fahr. for long periods at a speed of 30,000 r.p.m. and experimentally at 53,000 r.p.m., which illustrates the high strength of certain of the austenitic alloys at elevated temperatures. Fatigue, torsion, and tension tests show them to be several times as strong as the usual engineering steels, and even two or three times as strong as many of the complex alloys that are not of the naturally austenitic variety.

In uses where continuous or intermittent subjection to high temperatures, say, up to 1600 to 2000 deg. fahr., causes very rapid deterioration due to oxidation, they have proved very useful as in enameling racks, conveyor chains, hardening trays, and furnace-bottom plates. In this category might be included glass molds, but not all kinds of glass molds.

In automotive- and oil-engine valves they not only withstand the temperatures involved but also oxidation and scaling, and have good strength at full temperature. In connection with the Government's experiments in atmospheric-nitrogen fixation, it was found that among many metals tried some of these austenitic steels were the only ones that did not fail from intergranular penetration by the hot reducing gases. In short, as regards high physical properties at high temperatures and resistance to chemical attack likely to accompany elevated temperatures, they present some wonderfully interesting possibilities, but we do not know all their possibilities or limitations yet.

In conclusion, I have tried to show in the earlier part of this address that industry may and does suffer from the overzealousness of its own devotees when not supported by experience and sound judgment. Paraphrasing Woodward, we may say that from personal experience not only American science but American scientists are usually quite eminently respectable, but we may gain in popular esteem if we will display a more sympathetic interest in the work of our fellow-scientists in all fields and get away from too narrow specialization and selfish interests. Meetings such as this must foster this desirable end.

In the latter part, it has been my aim to show some of the results of metallurgical endeavor and I feel that Dr. W. R. Whitney stated the matter correctly when he said: "Necessity is not the mother of invention; knowledge and experiment are its parents. High-speed cutting tools were not a necessity which preceded, but an application which followed, the discovery of the properties of tungsten-chromium-iron alloys."

Metallurgical experiments made possible the automobile and airplane, and high-speed steels made their cheap production possible, and the materials are available for high-temperature use, although we do not know as much about them as we should, and much more intensive work is to be done.

Some day the American scientific research worker may become generally respected, and so far forget his modesty as to assume that the poet had him in mind when he wrote:

> No more a wind-borne leaf upon the waves
> Of time and chance, but one to whom is given
> To help the mighty purpose of the world
> To straighten crooked paths, to smooth the hills
> Of sin and sorrow, that on some bright day
> The great wheels of the world may run their course
> Without one jar to check.

The Engineering Scene[1]

A Critical Glance at Technical Education in Europe and How We May Profit by It

By WILLIAM E. WICKENDEN,[2] NEW YORK, N. Y.

The American and Canadian engineering colleges—120 strong—are now engaged in a large-scale study aiming at readjustments of organization and practice which will make them more efficient factors in our educational and economic life. It was my privilege to spend eight months in Europe as their representative.

One begins such a mission by expecting to find some things done better, which we may borrow or imitate to our profit. He ends by finding the possibilities of direct borrowing to be very scant indeed. The fundamental conditions are different. Educational systems are organisms, not machines. They are evolved rather than assembled by deliberate design. They cannot be disassociated from the economic and cultural environment in which they have developed. They cannot be taken apart and transplanted piecemeal.

I

The first thing that an observer discovers is that his task goes beyond the mechanics of plant and curriculum, the details of teaching and examination, important as they are, to the broader problem of technical education as a factor in the economic programs of the several nations. The value of such a study has to be found in the detached base line it affords for a criticism of our own work. The most general criticism of our engineering education that I have to make is that we have conceived it too narrowly, too much as a type of teaching process and too little as a vital factor in our economic life. We have been so preoccupied with our own subjects, our own departments, our own institution, that we have given all too little thought to technical education as a whole.

The result of this preoccupation with detail and unconcern with the general situation of which all of us have been guilty is that we have gotten a national, standardized system of technical education by sheer imitation and not by intelligent design. A few great pioneer institutions, carefully designed by their founders to fit the educational and economic needs then existing, have been uncritically copied from one end of the land to the other. The result is a wofully top-heavy system. We have too many institutions attempting pretentious programs of advanced professional training, and nowhere near enough giving substantial industrial training intermediate between the high schools and the professional schools of engineering. Germany, with her 65,000,000 people and her intensive industrial system, makes out with ten polytechnic schools and two mining schools of university grade, but there are between twenty and thirty admirable *Technicums,* middle schools of the Pratt Institute type, enrolling in the aggregate as many or more students than the schools of highest grade. In Great Britain the contrast is even more striking, it is positively the reverse of our situation. Students of engineering schools of university grade do not exceed 2500 in the aggregate, while the number in technical schools of junior and intermediate grade is between ten and fifteen times as great.

The top-heavy situation in America is further revealed by the fact that the majority of the students entering our technical colleges find the elaborate four-year program to be an impossible program. Out of one hundred freshmen who enter an average engineering college, only twenty-nine will be in the commencement procession

[1] Abridged from an article in *The Technology Review,* vol. 28, no. 3, pp. 143–148.

[2] Director of Investigation, Society for the Promotion of Engineering Education.

four years later. Some will succeed by taking an extra year and some will be replaced by men coming on advance standing from the arts colleges, but nearly two-thirds of the entire lot go through the sieve and get their preparation for life by failing to reach their objective.

There are valuable by-products, of course, but altogether too much waste—waste of costly educational facilities and tragic waste of the irreplaceable years of youth. The evidence we have been gathering in this country and abroad is leading me to the conviction that we need better engineers, a smaller number of men than we are now graduating with decidedly better training, and that we need a much larger group with a briefer, more intensive, and more practical training. We need to give the majority of the students who flock to our engineering colleges a less elaborate program at which to succeed instead of fail, but we need to give the minority, and perhaps an even smaller minority than at present, who survive to graduation a broader as well as a deeper training. The whole structure of our technical education needs more elasticity if it is to meet the needs of our youth on one hand and the needs of our industry on the other.

II

But we are supposed to be discussing Europe rather than America. If one were to judge by the visible scars which remain he could never make himself believe that Europe had experienced any such cataclysm as the late war. The material restoration of the ravaged areas is nearly complete. The mines and industries of northern France are now well above the prewar level of production. Germany engineered the inflation period so as to completely liquidate the middle classes and to fix her negotiable wealth in a form which could not be removed from the country. Consequently her industrial equipment and her transport facilities, by highway, water, and rail alike, are in an admirable state of renovation. In Italy the Fascisti have undertaken a program of reclamation of land and development of resources on a most extraordinary scale, aiming at a goal no less than the making in Italy of a home for the fast-multiplying Italian people.

The legacies of the war are plainly social, political, and economic. Individuals are much the same as before, but institutions are profoundly shaken. If one would understand the present trends of technical education abroad he must do so in the light both of tradition and national programs of industrial recovery and expansion.

One would seek in vain for indications of a program of expansion in the upper levels of French technical education. Admission to the conspicuous schools, especially those in Paris, is eagerly sought for, but is rigidly restricted and intensely competitive. The French consider it both wise and just, in a land already highly developed and having no great program of industrial aggrandizement, to protect the engineering profession from dilution by definite restriction at the source of recruitment. Higher technical education, like all other higher education in France, has a strong intellectual bias. Admission is restricted to a selected elite. The schools pride themselves on the professional distinction of their professors, most of whom are not teachers by career but active practitioners who receive only nominal salaries and serve primarily for honor. The instruction has a strong mathematical and theoretical emphasis, partially balanced by the solution of engineering problems of substantially real magnitude. French laboratories, for the most part, are rather meager. A few of the most modern installations indicate that the French know how it should be done, and give support to the ever-present excuse of public poverty.

These characteristic virtues—teachers of high intellectual and professional distinction, restriction of admission to the mentally gifted, great theoretical emphasis and a régime of almost military rigor—together with the corresponding defects, such as paucity of material equipment, meagerness of practical experience, absence of an adequate recreational life and the lack of organized student activities to provide a sort of experiment station for self-discovery and self-expression, run all through French secondary and higher education.

Technical education of the middle grade, so meagerly developed in America, is relatively well provided for in France and is of excellent quality. The French have dignified technical education by the appointment of a spceial under-secretary of state, but his efforts are devoted to the development of an adequate national system of apprenticeship for the manual crafts. Quality and not quantity production, skilled handcraft and not standardized specialization of labor, organization on a modest scale and not mass organization, bid fair to remain the industrial ideals of France.

III

While it would be plainly improper to rank Italy at the front of the great powers of Europe, she probably leads them all in her present rate of material progress. Higher technical education has been in the direct path of this movement. Italy is par excellence a land of builders. Her traditions and her program give civil engineering a dominant place, but electrical engineering is coming to the fore as a strong second. The other branches are developing slowly and are still far in the rear, unless it be naval architecture, in which the Italians have great ambitions.

The polytechnic schools of Italy, like those of Germany, are coordinate with the universities. The first two years of the five-year course may be taken in either type of institution. In point of equipment, personnel, standards, and morals the Italian polytechnics quite outran my expectations. Milan is rebuilding and Padua and Turin expanding on the most modern lines. The professors are mostly teachers by career, and are men of great devotion and fine personal qualities. The present low exchange rate has drawn to Italy a great colony of foreign students formerly established in Germany.

Italy has done one interesting and unique thing: she has made engineering a legally closed profession to all except the graduates of her polytechnics and similar institutions. The first year after graduation is to be spent in subordinate employment, after which a state examination opens the way to professional licensure.

IV

Switzerland stands supreme in Europe and perhaps in the world in the application of organized intelligence to a severe problem of national economics. Wholly devoid of natural resources, except her soil, an abundance of rock, her modest forest reserves, her water power, and her scenery, she is yet the supreme example of evenly distributed modern comfort in her scale of living. Her industrial system, based on the application of the maximum of highly trained intelligence and skill to the minimum of imported raw materials, is a wholly unique example of deliberate economic selection. That is another way of saying that Switzerland is probably the best engineering country in Europe. The famous Polytechnic Institute at Zurich and the numerous technical middle schools which dot the several cantons have been direct factors in this scheme for technical education of all the countries east of the Rhine, and maintain their place among the most noteworthy in Europe today.

In Czechoslovakia one finds the leading exponent of the Slavic renaissance. A fair land of fertile plains and forested hills, well endowed with mineral resources, with an intelligent and skilled population, she was the industrial heart of the old Austrian Empire. Today she combines the artistic and intellectual traditions of her own past with an efficiently organized educational system inherited from the Austrian régime.

The Czech technical schools are decidedly strong in civil and mechanical engineering. There is no dearth of notable professors such as Melan and Doerfel, and they serve with great devotion for meager salaries, although the material facilities are of the most modest nature. Herein is the greatest contrast to our American schools, incomparably rich in equipment, but far too often staffed with second-rate men.

V

Industrial Germany must be pictured as a powerful economic machine, expanded during the war and rehabilitated during the inflation period. She lacks only working capital, raw materials, and markets to rival our own industrial system.

I can only suggest as a bare catalog the salient features of her higher technical education—the rather exceptional qualifications of the professors, largely drawn into teaching from practice instead of being promoted up an academic ladder; the free régime of work under which the student comes and goes as he pleases; the absence of a fixed curriculum, but in its place two comprehensive groups of

examinations to be passed; the three characteristic types of instructions, namely, lectures, practical exercises and semi-independent projects of analysis and design; the simplicity of the scheme of organization, with its absence of detail records and disciplinary regulations; the large amount of original work in progress in the laboratories and the correspondingly numerous doctor candidates; the unique resources of certain laboratories which have grown up through the coöperation of the industries and the state with particular professors of wide reputation; the strong emphasis given to training in engineering design; the absence of the textbook and cookbook laboratory system; the growing interest in student housing and welfare; the rudimentary beginnings of a system of athletics and other student activities; the persistence of the dueling system—it is a theme that needs an entire paper to do it justice.

The great and outstanding fact about German technical education is its tremendous expansion. The great gain in enrolment in electrical and mechanical engineering is indicative of the immense development in manufacturing and the intensive mechanization of agriculture on which Germany stakes her economic future. The whole country seems to have made up its mind that the most hopeful outlook for a career for a young German is in the manufacturing industries, with the result that these branches of engineering are attracting the greater part of the group who under the old régime would have sought officers' careers in the army or navy.

It seems plain, however, that Germany cannot possibly absorb all her young engineers at home without degrading many of them to menial positions. In all probability she will send abroad large numbers of young engineers to serve as the advance agents of her economic penetration. Our young engineers will be face to face with them in every foreign market, and they may be face to face with them in no small numbers in our own industries.

VI

The shortness of our time will compel us to fly over Belgium and Holland without a stop, in order to dwell for a brief period in Britain before coming to our conclusion.

Britain is beginning to scrutinize her industrial set-up, and with it her system of technical education, with a new and critical seriousness. British engineering and British industry have a great tradition of practicality. An engineer has been regarded as a practical builder, primarily the product of the factory, the mine or the field of civil construction, with enough native curiosity and energy to get some insight into the science underlying his craft. Until quite recently there had been a distinct divorce between university education and engineering. Universities were supposed to be for gentlemen and scholars, while engineers were presumed to be neither, in the narrow and technical sense of the oft-used terms. Of course, there were notable exceptions, like Sir Charles Parsons, but for the most part higher technical training was looked upon with doubtful favor by the dominant men in the engineering profession.

The great genius of Britain in the field of technical education has been expressed in its numerous local technical schools, which serve mostly as continuation centers to supplement training through practical apprenticeship. Education of this type has very substantial virtues, as the results of the Lowell School here at the Institute will testify, but it has one fundamental defect—it tends to dissociate engineering training from high scientific culture and research. In recent years British industry has begun to suffer obviously from this divorce from science. There is now a marked tendency to foster university work in engineering and applied science. Laboratory facilities are being improved, graduate students, are multiplying, and engineering research is being pushed concertedly and with vigor.

VII

By way of summary and conclusion, let us recapitulate some of the more striking contrasts between higher technical education here and abroad.

1 We have an unbalanced and top-heavy system, the result of imitation and the absence of any coördinating control comparable to the European ministries of education.

2 Because our system is top-heavy, a good deal of it is pretentious. An insatiate craving for prestige, even though it may be hollow, and uncritical emotionalism characterize too much of our entire scheme of higher education. In comparison, European educators are realists.

3 We have little to learn abroad as to material equipment, except in a few special laboratories in Germany. We might learn, however, how far short we fall of getting the full possibilities out of our investment.

4 We are in real danger of exalting material equipment and perfection of teaching routine above men, as the foundation of our work. Getting the men is apparently harder than getting the things. It is partly a matter of compensation, of salaries above the level of meanness, but it is far more a matter of the nature and circumstances of our type of professional career, and it is most of all a problem of creating a national tradition which gives generous recognition and reward to non-commercial types of achievement. As it is we do not pay in money and we do not know how to pay in honor.

5 We have to compensate for the results of a scheme of secondary education which, however admirable in its widely inclusive democracy, is comparatively flabby and superficial. In point of mental maturity and discipline, extent of knowledge, and capacity for hard work, the European youth of eighteen is nearly two years in advance of our own. By intensive methods and a crowded schedule we recover about half the deficit in our four-year programs and send our graduates out on an approximate par with the product of a three-year program in Great Britain, somewhat behind the product of the best three-year programs in France, and practically a year behind the diploma engineer from the four-year programs of Germany, Austria, Switzerland, Holland, and the Scandinavian countries.

6 We shall lag in the higher stages of technical education unless we can get our abler students to assume much more initiative. Our whole set-up tends to become a scheme to *give* students an education. Too often our colleges are highly elaborate schoolhouses, our students are overgrown schoolboys and our professors glorified schoolmasters. The take-it-or-leave-it program abroad assumes that students are expected to *get themselves* an education, under the guidance of creative men and in an environment of real intellectual production.

7 The American and the British students have a decided advantage over the continental students in physical development through athletics and in general development derived from other extra-curricular activities. Speaking broadly, the American graduate fits into the teamwork of business and practical life more readily than the continental diploma engineer, but he is apt to have an inferior grasp of theory and fundamentals and to be less capable of working independently.

8 Training in design by full-scale project work bulks much larger in the continental scheme than in Britain and America. Our men get a more extended training in shop and laboratory technique, although much of it is deficient in analytical qualities.

9 Continental Europe depends on the higher technical schools as centers of research and original work far more than America or Great Britain. The large-scale industrial-research laboratory is essentially an American institution, and, educationally considered, something of an American handicap.

10 Both professors and students abroad have more freedom than with us. Professors work under an ethical code which obligates them to devote all their efforts to the advancement of their special fields of knowledge. Their fixed appointments are fewer, but they direct a volume of work limited only by their creative ability and their power to draw disciples about them. Except in France and Italy, students abroad are free to attend or stay away. They work on long-range assignments of work rather than day-to-day instalments. Examinations of comprehensive scope, rather than detailed daily records, are the measure of their achievement and progress.

In conclusion, I find myself drawn to the conviction that we have a program of technical education which is well suited to a considerable group of our students of a medium grade of ability. The present program is plainly too long and too complex for a large group of lower powers. But there is a third group, not large and probably not as large as it should be, young men of high native ability and mental energy. We need a better program, a freer program, for these men, and in providing for them we have most to learn from our colleagues across the Atlantic.

Transmission of Power on Oil-Engine Locomotives—I[1]

By ALPHONSE I. LIPETZ,[2] SCHENECTADY, N. Y.

Power transmission on oil-engine locomotives depends upon the type of the oil engine for the locomotive and upon the conditions under which the locomotive is going to run.

The present paper pertains to the transmission of power only, and gives a classification of power transmissions in the chronological order of their appearance in the art.

Class A comprises full-power elastic-fluid transmissions in which the total output of the oil engine is transferred into elastic-fluid energy, which is in turn utilized for the propulsion of the locomotive. The efficiency of such a transmission is the product of the two separate efficiencies of the generation and utilization of energy. Various types of electric, hydraulic, pneumatic, compressed-steam, aero-steam, and compressed-exhaust-gas transmissions are described.

Class B consists of differential elastic-fluid transmissions in which the power from the oil engine is transferred directly to the driving wheels at top speeds of the locomotive with a very high efficiency, and partly directly and partly indirectly at all intermediate speeds. The theory of such transmissions is expounded and formulas for torques, speeds, and efficiencies are derived. Examples of electric, hydraulic, and pneumatic transmissions of this type are described, and results so far obtained are given.

Class C pertains to mechanical (gear-clutch) and direct transmissions.

The drawing of conclusions as to the possible fields of application of various types of transmissions is postponed until the questions of the types of oil engines and different conditions of locomotive performance on railroads are discussed in a separate paper.

ONE WHO is familiar with the progress made in the present century in the domain of heat engineering and prime movers must be exceedingly surprised at the fact that the internal-combustion engine, having conquered practically all means of transportation—by air, by road, and to some extent by water—has not as yet gained any foothold in the most important line of transportation, namely, that by rail. Considering the fact that the Diesel engine is the most economical prime mover of our present age, and that, on the other hand, the reciprocating non-condensing steam engine of the present-day locomotive is far from approaching the efficiency of the latter, one cannot help but wonder why it is that the Diesel locomotive has not yet come into being, although almost thirty years have already elapsed since the first marketable Diesel engine was built.

There are several reasons to account for this fact, but, briefly, all of them can be reduced to one, namely, that the steam engine is a very flexible machine, making the steam locomotive a wonderfully adaptable and convenient means for railroad traction, whereas the Diesel engine is the most inflexible prime mover. As is well known, the Diesel engine is a constant-torque prime mover and the torque cannot be appreciably increased; neither can the engine start under load. This either makes direct coupling of driving wheels with the engine brake shaft impossible, or requires special devices in order to overcome the above-mentioned handicaps of the Diesel engine. It is to these devices that the tardiness of the development of the Diesel locomotive must be attributed.

There are several sides to the problem of the Diesel locomotive: the Diesel engine, or broadly speaking, the oil engine, is one question; the torque-varying devices, or the transmission of power from the oil engine to the driving wheels, is a second; and the cooling of the oil engines on the locomotive is a third. We shall consider each of the three questions, but in order to facilitate the discussion of the oil engine itself, we shall take up first the various transmission systems, as the type of oil engine depends largely upon the system of power transmission employed. The other two questions will be discussed in a separate paper.

[1] Presented at the Spring Meeting, San Francisco, Cal., June 28 to July 1, 1926, of The American Society of Mechanical Engineers. Part II, dealing with Class B and Class C transmissions, will appear in the September issue.

[2] Consulting Engineer, American Locomotive Co. Mem. A.S.M.E.

Power Transmission

Owing to the inflexibility of the Diesel engine, the most natural thing to do is to use some sort of flexible power transmission in which a new intermediate energy is generated (electricity, hydraulic pressure, etc.) and immediately expended, thus permitting a variation of torque and speed at will. Such a system requires in addition to the full-power oil engine two more full-power machines—a generator, pump, or compressor, as the case may be, and a corresponding electric, hydraulic, or pneumatic motor. Assuming that a direct transmission of power by mechanical means is not possible, the full-energy power transmission seems to be the only feasible solution. However, in speaking of the inflexibility of the oil engine, we must not forget that the latter is not absolutely, but only relatively, inflexible, and that it can be regulated within certain limits—about 15 per cent above normal and about 75 per cent below normal. Consequently there would be a certain range within which a direct mechanical transmission of power would seem possible. Therefore there is a certain class of power transmissions in which the power is transmitted partly mechanically and partly through an auxiliary medium (electricity, oil, etc.); these transmissions have the advantage of using smaller auxiliary generators and motors and of giving higher efficiencies within the range where the mechanical transmission of power is mostly used.

Further, attempts have been made to make the oil engine more flexible in order to permit the use of direct mechanical transmissions. While such attempts have not yet passed the stage of preliminary trials, nevertheless they merit the most serious consideration as they may lead to the most desirable and most promising solution.

Thus we have three classes of power transmissions for oil-engine locomotives:

A Full-power, elastic-fluid transmissions
B Differential elastic-fluid transmissions
C Mechanical and direct transmissions.

CLASS A—FULL-POWER ELASTIC-FLUID TRANSMISSIONS

1—Electric Transmission

The electric transmission is, of course, the most orthodox, the most thoroughly studied, the best worked out in all details, and the readiest to use. The idea is not new, as all component parts have been known for a long time and have proved separately their reliability during many years of service. A complete design of a main-line locomotive was worked out by the Kolomna Works in Russia as far back as 1909. The Kolomna Works were at that time very active in building marine reversible Diesel engines for motorships on the Volga River, and being at the same time important locomotive builders, they naturally became interested in Diesel locomotives. The design, however, when fully completed, did not encourage either them or the Russian Railways to build a locomotive because of the excessive weight and cost. Several similar designs were worked out independently by other locomotive and Diesel-engine builders in Russia during the period of 1910 to 1914, but none of them ever materialized. Nor were Diesel-electric locomotives built at that time anywhere else.

Electric transmission, though, was widely used in railway motor cars with gasoline engines up to 150 hp. and running at from 1000 to 1500 r.p.m., both in this country and in Europe; but as we are not concerned here with gasoline locomotives, these motor cars will not be discussed. As regards Diesel-electric cars and locomotives, the following types were later built and tested:

a The first combination of a heavy-oil engine and an electric transmission is found in a Diesel-electric motor car built in 1913 by the Swedish General Electric Company (Almänna Svenska Elektriska Aktiebolaget) in conjunction with the Diesel Engine Company (Aktiebolaget Atlas Diesel). Later the two firms organized a new company, the Diesel-Electric Car Company

(Diesel Elektriska Vogn Aktiebolaget), known as DEVA, and since 1913 about thirty cars have been built for Sweden, Denmark, France, and Tunis. They were built of various sizes—from 60 to 120 hp. as motor cars with compartments for passengers and for mail and baggage, and from 150 to 300 hp. as locomotives with compartments for mail and baggage only.

In all these cars the Diesel engine is of the Swedish "Polar" type. It is a four-cycle single-acting engine with air-blast injection, developing at 500 to 600 r.p.m. 15, 20, 25, and 30 hp. per cylinder, making thus 4, 6, 8, and 12 cylinders for the above-mentioned outputs. Except the 60- and 90-hp. engines, which have one row of vertical cylinders, all other engines are of the V-type, in which two cylinders in each transverse row drive one common crank. The electric generator is in line with the engine and is connected with it by a flexible coupling. The generator is of the eight-pole shunt-wound type, provided with a separate series winding which is used for starting the oil engine by driving the generator as a motor from a storage battery for a short time (1 to $1^1/_2$ sec.). Except the 60-hp. car of the 2-2-0 type, which has only one motor, all other cars have two motors with a 2-4-0 wheel arrangement for 150-hp. and a 2-2 + 2-2 one for all other sizes. All motors are of the traction type, completely enclosed, with the casing in two parts, suspended on one end to the frame and on the other end supported by and geared to the driving axles. The speed control is obtained by varying the excitation through a controller on either end of the car, or locomotive.[3] On the large cars the motors, which are usually coupled in parallel, can also be coupled in series in order to provide a larger traction effort.

The fuel consumption is between 2.0 and 3.5 lb. of oil per 100 gross ton-miles. According to reliable information from two Swedish railroad companies, this represents an economy in money of 50 to 60 per cent as compared with coal-steam operation.[4] The cost of maintenance of the machinery is very low. For the oldest DEVA motor car, which has been in service since August, 1913, the total maintenance cost amounts to 2.16 cents per car-mile. At present there are in Sweden in operation altogether 14 DEVA cars on some eight small railroads. A complete report of their performance was published by M. R. Jourdin, general manager of the French South-Eastern Railway, after a visit to Sweden in September, 1922.[5] His figures are in conformity with those given above, as are also the results obtained from one of the latest DEVA locomotives delivered in 1924 to the Railway Company of Tunis.[6]

b Very soon after the appearance of the DEVA motor cars, several Diesel-electric motor cars were built for the Saxon and Prussian Railways by Sulzer Bros. in Winterthur, Switzerland, jointly with Brown, Boveri & Co. in Mannheim, Germany. They were first placed in service in 1915. The prime mover was a six-cylinder, V-type, four-cycle, air-injection Diesel engine which developed 200 b.hp. at 440 r.p.m. A direct-current, 140-kw., 300-volt, eight-pole generator capable of a 190-kw. output for one hour was directly connected to the engine brake shaft. A separate 7.5-kw. exciter supplied also current for a fan and for charging a 95-ampere-hour storage battery. The latter was provided for starting the Diesel engine by reversing the generator for a short time and operating it as a motor. Two six-pole series electric motors were set on a jackshaft mounted on the rear four-wheel truck and connected with both driving axles by means of connecting rods. Each motor was rated at 80 hp., and the output could be doubled for a period of one hour. For speed control a modification of Ward Leonard system was used, which consisted of varying the excitation of the generator and reversing the flow of current through the armature of the motors.

Tests made with the car on the Saxon Railways showed a fuel-oil consumption of 2.92 lb. per car-mile, or 3.86 lb. per 100 ton-miles.[7]

[3] Diesel-Electric Motor Cars, by E. Nilsson, *Railway Review*, August 29, 1925, pp. 301–307.

[4] Application du Moteur a Hydrocarbures a la Traction sur Voies Ferrées, by M. E. Brillié, *Revue Générale des Chemins de Fer.*, May, 1924, pp. 396–398.

[5] *Revue Générale des Chemins de Fer*, September, 1923, pp. 187–202.

[6] Locomotive Diesel-electrique en Service en Tunisie, by M. R. Debize, *Revue Générale des Chemins de Fer*, March, 1924, p. 172.

[7] Die Diesel-elektrischen Triebwagen für die Kgl. Sächsische Staatseisenbahnen, by H. Zeuner. *Elektrische Kraftbetriebe und Bahnen*, Heft 26–28.

Nevertheless, new orders for motor cars did not follow, and in 1921 the Sulzer firm bought back from the Saxon Railways two motor cars and rebuilt them. They eliminated the air compressor and replaced the fuel valve by a pressure-controlled solid-injection valve. No other essential changes were made. One of the cars was used for demonstration purposes and the other, it has been said, was sold to the Swiss Federal Railways. The Sulzer Bros. tests have shown a fuel consumption of 0.446 lb. of oil per hp-hr., measured on the shaft of the engine. They estimate the total efficiency of the electric transmission (generator and motors) together with the mechanical transmission (rods, pins, and axles) as 72 per cent, corresponding to a total consumption of oil of 0.62 lb. per rail hp-hr. They further say that the consumption of oil per 100 ton-miles is equal to 1.9–3.2 lb., and that this corresponds to only one-fourth of that on regular steam locomotives in Swiss suburban traffic.

c At the end of 1923, a 300-hp. 0-4-4-0 Diesel-electric locomotive was placed in railroad service in this country. The locomotive was built jointly by the General Electric Company and by the Ingersoll-Rand Company. The locomotive actually represents a further development of two locomotives built by the General

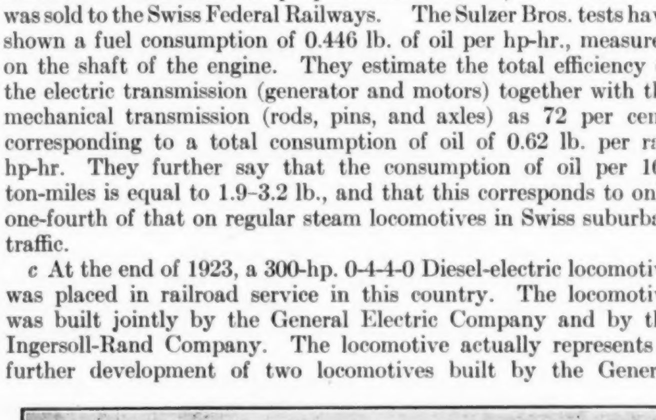

Fig. 1 Oil-Electric Locomotive, Jay Street Connecting Railway

Electric Company in 1917 and 1918, which were doing regular yard switching work at the Erie works of the company. One of these, the Jay Street locomotive, is shown on Fig. 1. The body of the other, which was called "Oil-Electric Motor Car No. 4," was used for the 300-hp. locomotive of 1923. Several other locomotives, practically duplicates of the last-mentioned one, have been built since 1923 by the same two companies jointly with the American Locomotive Company. In these the prime mover is a six-cylinder, four-cycle, single-acting oil engine with airless injection built by the Ingersoll-Rand Company. The engine develops 300 b.hp. at 600 r.p.m. and weighs only 19,355 lb., or 64.5 lb. per b.hp. One oil-fuel injection pump serves all six cylinders through a properly times six-feed distributor of a special design. Each cylinder has a separate combustion chamber with two opposed spray nozzles, the combustion chamber being connected with the cylinder by a narrow neck for creating turbulence and proper combustion (Price-Rathburn system). The generator is a 200-kw., 600-volt, compound-wound, 6-pole, direct-current dynamo directly fastened to the oil-engine brake shaft. There are four geared motors, one for each axle, mounted on the trucks. The motors are of the series-wound, totally enclosed, commutating-pole, split-frame type, rated 95 hp. at 600 volts. They are arranged in two pairs, which are permanently connected in multiple, and these pairs can be coupled in series usually for speeds below 5 miles per hour, or in parallel for speeds above 5 miles per hour. The output of the generator is automatically adjusted to suit the varying train resistance. This is done by inserting a commutating field and a differential series field in the current line, thus modifying the excitation field of the generator so as to give the proper proportion of amperage for the tractice effort and of voltage for the speed. No rheostats are used in the power circuit for speed control. The position of the control handle determines only whether the motor are connected in series or in parallel or in reverse, and another handle, which is the only operating handle, affects the throttle controlling the power generated by the oil engine. Further speed

control goes on automatically with the proper division of power into tractive effort and speed.[8] This system, known as the automatic or the Lemp control, has been used very extensively by the General Electric Company for gas-electric motor buses, motor rail cars, and locomotives. The automatic control was fully described by Herman Lemp in his paper Electric Transmission for Internal-Combustion Engines, presented at the annual meeting of the A.S.M.E., December, 1925, and published in Mechanical Engineering, Vol. 48, No. 3, March, 1926, p. 207.

The first 300-hp. 60-ton oil-electric locomotive has been doing switching work on various roads in this country—the New York Central, Baltimore & Ohio; Central Railroad of New Jersey; New York, New Haven & Hartford; Boston & Maine; Long Island; Philadelphia & Reading; Delaware, Lackawanna & Western; and others. It has shown very good results, the cost of operation being much lower than that of ordinary steam switching locomotives with their large stand-by losses. The fuel consumption per generated kilowatt-hour fluctuated from 0.105 to 0.191 gal. of fuel oil, this wide fluctuation being due to the variation of load factor in switching service (the latter ranged from 8.47 to 30.5 per cent). However, on August 14, 1924, a tonnage test was made on the New York Central Railroad with a load factor of 91 per cent which gave a more reliable consumption figure, namely, 0.092 gal. of fuel oil per kw-hr., this corresponding to 0.514 lb. of oil per brake-shaft hp-hr.

A very interesting comparison in dollars and cents of the cost of operation of the 60-ton oil-electric locomotive with a steam locomotive was made on the Long Island Railroad, when two sets of data referring to switching service of these two locomotives were collected. For practically the same amount of switching work the fuel, water, and lubricating-oil cost amounted to $30.51 for the oil-electric locomotive, and to $106.71 for the steam locomotive.[9] This represents a saving of 71.5 per cent. A comparison of operation cost of a similar 60-ton oil-electric locomotive with that of a steam locomotive during 24 days in December, 1925, at the Bronx Terminal of the Central Railroad of New Jersey, showed that the average cost of fuel, oil, coal and water was $0.228 for the oil-electric locomotive and $1.18 for the steam locomotive; the saving in fuel, water and lubricants thus amounted to 80.7 per cent. The further development of the 60-ton oil-electric locomotive will be given later.

d A great stride in the development of oil-electric traction was made when the 1000-hp. locomotive[10] for Russia was built in 1924 in Germany. This locomotive is of the 2-10-2 type. The prime mover has six-cylinders, $17^3/_4$ in. (450 mm.) bore by $16^1/_2$ in. (420 mm.) stroke. It is a four-cycle air-blast-injection engine of the submarine type, developing its full power (1000 hp.) at 450 r.p.m. The direct-current electric generator is connected directly with the Diesel engine. The exciter is driven from the generator shaft by means of wheels with a ratio of 1:2. The field of this exciter is in turn energized by another small exciter driven by a belt from the shaft of the first exciter. The field of the latter exciter is fed by a current from a storage battery through controllers placed in the engineer's cabs at both ends of the locomotive. Thus a very gradual change in voltage is obtained which, as a consequence, gives a very flexible control of speed and tractive effort with small resistance losses in the electric transmission. Five direct-current electric motors of the tramway type are geared to the driving axles, one motor to each axle.

The locomotive weighs 133 tons, of which 100 tons is weight on drivers and 33 tons that on front and rear supporting axles. The weight of the electric transmission and control amounts to 51.2 tons. The locomotive develops from 840 to 890 rail hp. at the maximum output (1200 hp.) of the oil engine.

[8] New 60-Ton Oil-Electric Locomotive, *Oil Engine Power*, September, 1925, p. 513.

[9] *Oil Engine Power*, July, 1925, p. 410.

[10] The power of this locomotive is very often given as 1200 hp. This seems to be the maximum overload rating of the Diesel engine, as it corresponds to 86.4 lb. per sq. in. brake m.e.p. For continuous output, the author thinks it more correct to rate the Diesel engine at 1000 hp. in agreement with Dr. Ing. M. Mayer, manager of the Maschinenfabrik Esslingen, builder of the locomotive (see his paper, Die Diesellokomotive vom Standpunkt des Lokomotivbaues, published in *Zeitschrift des Vereines deutscher Ingenieure*, May 9, 1925, p. 637). The 1000-hp. continuous rating corresponds to 72.0 lb. per sq. in. brake m.e.p., which is more in conformity with the rating of other oil engines mentioned in this report.

The Russian Diesel-electric locomotive was first tested on a stationary locomotive testing plant in Germany and later was sent to Russia for regular service. At the testing plant it ran under variable load at variable speeds, each variable being constant, however, during a certain continuous run. The average loads during a series of three trials lasting from 55 to 94 minutes were 467, 845, and 876 hp.; the corresponding tractive efforts were 9540, 20,400, and 33,600 lb. The consumption of fuel oil per rail hp-hr. amounted to 0.537, 0.525 and 0.558 lb., respectively, the latter figure including the oil for driving the cooling fans. The overall thermal efficiencies, including all auxiliaries and losses, obtained from numerous tests in addition to the three mentioned above, ranged between 18 and 24 per cent. The efficiency of the electric transmission itself fluctuated normally between 73 and 85 per cent, although occasionally efficiencies of 93 per cent were recorded.

Very elaborate comparative tests were made on the same testing plant with a 0-10-0 superheated-steam locomotive. At three different tests with loads, speeds, and tractive efforts approximately the same as those during the three trials with the Diesel-electric locomotive, the fuel-consumption figures were 1.87, 1.64, and 1.86 lb. per hp-hr. of the fuel oil used in the Diesel engine, or over three times as much as those of the Diesel-electric locomotive.[11]

As regards the performance of the locomotive in ordinary railroad service, information received from Russia indicates that it has been very satisfactory. The locomotive has shown very good starting and pulling qualities, great flexibility, and saving in fuel.

The locomotive has now been in main-line freight service for over a year and has proved to be very reliable. However, some troubles resulting from overheating of electric motors on long grades were experienced. The motors are likely to get hot at high tractive efforts and speeds below 20 m.p.h., whereas the air cooling of the motors is more effective at speeds over 20 m.p.h. The locomotive cannot be used continuously at full power at speeds less than 10 m.p.h. In some instances, on very long grades, the speed had to be raised and the tonnage correspondingly reduced.

Nevertheless, the mileage of the Diesel-electric locomotive proved to be 85 per cent greater than that of a steam locomotive of comparable size. The oil consumption in dollars and cents was about 30 per cent of that on steam locomotives burning fuel oil—a saving of 70 per cent. The expenses for lubrication were about six times higher than for the steam locomotive—this due to the Diesel engine—but as a whole they were negligible. The cost of the crew was higher than on steam locomotives, but owing to the larger mileage of the oil-electric locomotive, it was approximately the same per locomotive-mile.

The total result of the operation-expense sheet showed an economy of about 26 per cent per ton-mile as compared with steam-locomotive operation.

e At the time when the above-mentioned locomotive was under construction in Germany, an articulated 2-6-8-6-2 oil-electric locomotive was being built at the Putiloff Works in Petrograd, Russia, according to the design of Professor Hackel, and has been placed in service since. Unfortunately, no information regarding it is yet available.

f At the Fair in Milan, Italy, in the summer of 1924, a 400-hp. Diesel-electric locomotive of the 0-4-4-0 type was exhibited. It was built by Franco Tosi Societa Anonima, Diesel-engine manufacturers in Legnano, Italy. The prime mover is an eight-cylinder, four-cycle, single-acting oil-engine of the well-known Tosi design with air-blast oil injection, developing 400 b.hp. at 300 r.p.m. The engine is geared to two direct-current generators of 170 kw. each, delivering the current to four 95-hp. motors geared to four driving axles. The locomotive weighs 66 tons and is supposed to pull a train of 99 short tons (three eight-wheel cars on trucks) with a speed of 37 to 43 m.p.h. The locomotive seems to have run on the Molteno line in Italy, but very little is known about the performance of the locomotive.

g A similar 0-4-4-0 Diesel-electric narrow-gage locomotive was built by the Fiat Company for the Calabro-Lucane Railroad in Southern Italy. It is driven by a six-cylinder, two-cycle engine developing 440 b.hp. at 500 r.p.m. A 250-kw. separately excited

[11] *The Engineer*, Nov. 14, 1924, p. 554. See also Die Diesel-Elektrische Lokomotive, by Prof. G. Lomonossoff, Berlin, 1924.

generator is directly coupled to the Diesel engine and gives, at 500 r.p.m., a variable voltage of from 300 to 500 volts. Four motors of the railway type, rated at 72 hp. continuous operation, are geared to driving axles. The speed control is obtained by varying the excitation of the dynamo. The generator supplies power for the radiator cooling fans, for the air-brake compressor, for the water and oil circulating pumps, etc. A storage battery is used for starting the oil engine by temporarily reversing the generator into a motor, and also for driving the radiator fans when the oil engine is at standstill. The fuel consumption amounts to 0.47 lb. of oil per b.hp-hr. No further details are as yet available.[12]

h Quite recently the Baldwin Locomotive Works has completed a 1000-hp. oil-electric locomotive. It is of the 2-4-4-2 type and is driven by a 12-cylinder Knudsen oil engine through a Westinghouse electric transmission. The cylinders of the Knudsen oil engine are arranged in an inverted "V" with a double crankshaft. The engine is of the two-cycle single-acting type with airless fuel injection, each crankshaft having six cranks and rotating with the same speed and in the same direction by means of two spur wheels and an intermediate pinion. Each pair of cylinders located in one transverse plane have a common combustion space, and their cranks are so placed in relation to each other that the pistons travel downward and upward practically simultaneously, a slight lag being deliberately permitted for the piston controlling the scavenging-air inlet. Thus the scavenging air sweeps through the cylinders after the exhaust has already taken place, and it is expected that from the time the exhaust ports are closed the scavenging air fills the cylinders to build up new pressure. Another feature of the Knudsen engine is the cooling of the piston by the scavenging air. The cycle is essentially that of an opposed-piston engine.

The scavenging air is supplied by a General Electric turbo-blower driven at 3600 r.p.m. from the engine and delivering 4500 cu. ft. of air at $2^1/_2$ lb. pressure. The power required by the blower is 70 hp. Air for starting the oil engine and for the air brakes is supplied by a twin-cylinder gasoline-driven air compressor. The full power of the engine (1000 b.hp.) is developed at a crankshaft speed of 450 r.p.m., while the intermediate pinion on which the generator is keyed runs at a speed of 1200 r.p.m., thus reducing the size of the generator. The latter is of the Westinghouse direct-current type with a separate exciter. The speed control is obtained by the use of the original Ward Leonard system with separately excited motor fields. The controller handle varies and reverses the field excitation of the generator and thereby the rotation of the motors. It is linked with a throttle regulating the oil admission to the engine and thus controlling the output of the latter.[13] No data as to the performance, service or efficiency have been communicated. The locomotive weighs 275,000 lb., of which 180,000 lb. is the weight on drivers.

i One of the latest combinations of an oil engine with electric transmission has been employed in rail cars built for the Canadian National Railways. Seven 60-ft. single cars and two 102-ft. articulated cars have already been place in service. The engines are modified four-cycle solid-injection Diesel engines of the airplane type built by William Beardmore & Co., Ltd., London, England, and have four $8^1/_4$ by 12-in. cylinders for the small unit and eight cylinders of the same size for the large unit. The two engines develop 185 b.hp. at 700 r.p.m. and 340 b.hp. at 650 r.p.m., and weigh 15 and 16 lb. per b.hp., respectively.

These record weights were obtained not only by raising the speed but mostly by the selection of special material, such as forged aluminum, high-tensile steel, and special alloys. Whether these light engines will stand continuous heavy service, remains to be seen.

As regards electric equipment, the small unit has a 105-kw., 600-volt, direct-current, British Thomson-Houston differentially compound-wound generator with a 6-kw. 60-volt separate exciter, and two 150-ampere 600-volt General Electric motors which drive the front truck axles through helical gears. The car speed is controlled by the oil-engine throttle and the Lemp automatic control system. The operating handle controls the throttle and another handle connects the motors to the generator circuit in series or parallel, or in reverse. The large unit has a Westinghouse 200-kw. 600-volt direct-current differentially compound-wound generator with excitation from a 300-volt battery, and four 145-ampere 600-volt Westinghouse motors connected permanently in parallel and driving the front and rear truck axles through helical gears. The car speed is controlled by the modified Ward Leonard system—with constant engine speed by governor and by resistances in the main generator field and by eight electropneumatic switches. The starting of the oil engines on either car is effected by driving the generator as a motor from a battery. The weights of the cars are 101,000 and 188,000 lb., respectively.[14]

During the several months of service since last November the operation of the cars has shown that the large car can travel from 2.5 to 2.75 miles, and the small car from 4.5 to 5.0 miles, on one Imperial gallon of oil of specific gravity of 0.86, which corresponds to approximately 3.5 lb. of oil per 100 ton-miles. One of the large cars has recently crossed the continent over the Canadian National Railway, covering the distance from Montreal to Vancouver, 2937 miles, in 67 hours in a non-stop run of the oil engine. The average speed for the entire trip was slightly over $43^1/_2$ m.p.h.[15]

j A further development of the 60-ton 300-hp. oil-electric locomotive described above is a 100-ton locomotive of twice the power. One engine of this type has been recently delivered to the Long Island Railroad. The locomotive differs from the 300-hp. locomotive in that two 300-hp. Ingersoll-Rand oil engines instead of one are used, together with two 200-kw. 600-volt direct-current generators, each generator being directly connected to the corresponding oil engine. The motors are four in number as in the 300-hp. locomotive, but differ of course in size. They are rated 200 hp. at 600 volts, and are of the series-wound, commutating-pole type manufactured by the General Electric Company.[16] The locomotive was delivered in December, 1925, to the Long Island Railroad for switching work at Morris Park. It has not been in service for a sufficient length of time to make operation data available.

Before concluding this section on oil-electric locomotives the author would like to state that while American manufacturers were somewhat slow in taking up the problem of oil-engine locomotives, having left its development to the initiative and skill of European engineers, they have nevertheless made considerable progress since starting. True enough, they concentrated their entire attention on practically one type—with electric transmission, but they have already overtaken their European comrades. The General Electric Company and the American Locomotive Company have already delivered to railroads thirteen oil-electric locomotives of 300 and 600 hp., all of which are now in actual service, and have nine more under construction. In addition, these companies are together building two more locomotives of the 4-8-4 type: one with a 750-hp. Ingersoll-Rand, and another with a 800-hp. McIntosh & Seymour oil engine, and one of the 0-6-6-0 type with a 600-hp. opposed-piston two-cycle oil engine. Designs of higher powers are now under consideration. Another American firm, the Baldwin Locomotive Works, has completed and will soon turn over to an American railroad a 1000-hp. oil-engine locomotive to which reference has been made above. Oil-electric locomotives are now being placed in actual railroad service one after another, and although progress is slow, it is nevertheless sure.

2—Hydraulic Transmission

When the Diesel locomotive built in Germany in 1913 with the engine directly connected to the driving wheels failed to perform the required work for reasons which will be given later, the German Railway Administration was looking for some sort of a flexible transmission of power. The author does not know why electric transmission was not resorted to, but it happened at the time that Hugo Lentz had just brought out a design of a hydraulic transmission and the German Railway Administration decided to try it out. Accordingly a small 30-hp. Diesel locomotive with Lentz transmission was built, the tests were considered encouraging, and several more locomotives were ordered for experimental purposes.

[12] *The Engineer*, March 13, 1925, p. 308; *Oil Engine Power*, April, 1925, pp. 232–233.

[13] *Oil Engine Power*, September, 1925, pp. 523–527.

[14] *Railway Age*, October 17, 1925, pp. 695–699.

[15] *Railway Review*, vol. 77, no. 21, November 21, 1925, p. 775.

[16] *Railway Mechanical Engineer*, February, 1926, pp. 92–95.

a The 30-hp. Diesel-Lentz locomotive (Fig. 2) is a small 0-4-0 switching engine. It was built in 1921 by the firm A. Gmeinder & Co., Mosbach, Germany, which was reorganized later into the Badische Motor-Lokomotiv-Werke A.G. The locomotive consists of a three-cylinder, four-cycle Diesel engine built by Benz, with a Lentz hydraulic gear connected by means of coupling rods with two driving axles, and with a water cooler in front of the locomotive similar to coolers of the automobile type. The Benz engine is a three-cylinder Diesel engine simplified for application to locomotives and adapted to the use of heavy oils. It runs at a maximum speed of 500 r.p.m. and is provided with a flywheel and a governor. The engine shaft is located parallel to the longitudinal axis of the locomotive.

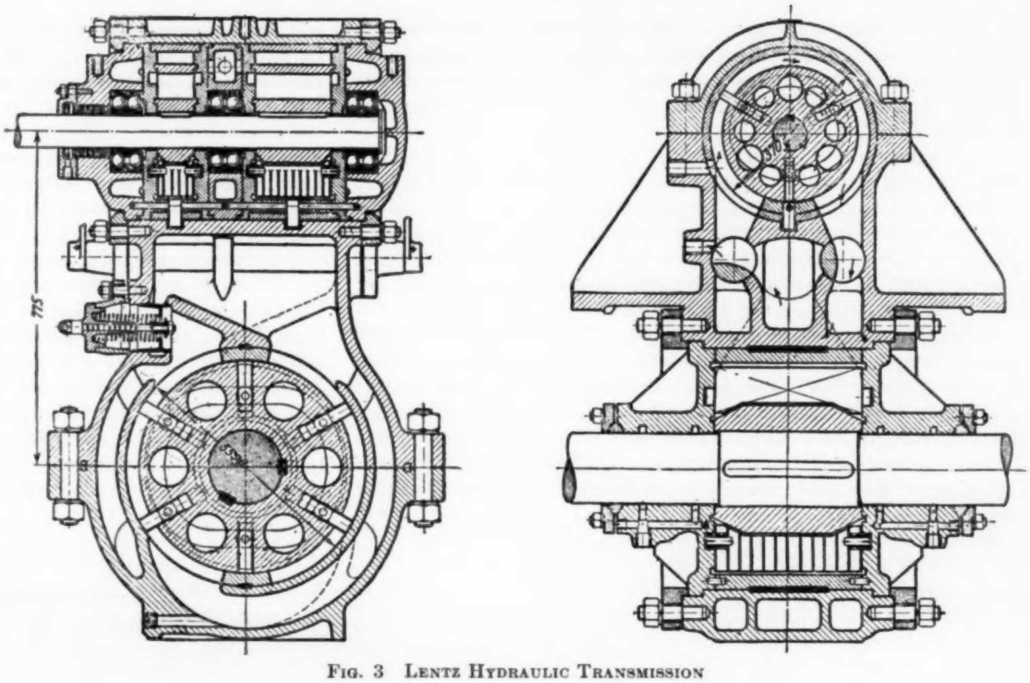

FIG. 3 LENTZ HYDRAULIC TRANSMISSION

The Lentz hydraulic transmission, or gear, as it is usually called for the reason that it does not change the speed of the propelled shaft gradually but stepwise, consists of two parts: a rotary pump attached to the prime mover and a rotary hydraulic motor connected to the driving (jack) shaft (Fig. 3). The pump is in line with the oil engine and has two or more revolving pistons (or one may call them disks) of different width. The motor has only one piston and its axis is parallel to that of the driving axles and at 90 deg. to the axis of the pump. Each piston has several very light sliding vanes which fit nicely in grooves in the piston. The disks revolve between nicely fitted covers made of hard bronze. The vanes are provided on both sides with pins and rollers which fit into grooves cut out in the covers. The grooves are made partly of a concentric, partly of an eccentric, shape. The motor has a similar arrangement but it usually differs in that it is made, double-acting with double the number of vanes. The fluid (lubricating oil) works in a circle; it is pumped into the motor and having performed its work it is led back into the suction passage of the pump. The speed of the motor is in proportion to the ratio of the volumes swept by the pistons of the pump and of the motor. If the pump is provided with two pistons with a ratio of volumes of 1 to 2, then three speeds of the motor can be obtained: (1) with the small piston only, the larger running idly; (2) with the large piston only, the smaller running idly; and (3) with both pistons running simultaneously. The ratio of the speeds would be 1:2:3. For the idle running of one piston or another the cocks should be placed in such a way as to establish communication between the pressure and the suction chambers of the pump; then the fluid passes through the pump only, with practically no pressure at all. By placing the cocks so as to connect the pump with the motor, the fluid is forced into the motor with a pressure corresponding to the load on the driving shaft and returns to the suction chamber of the pump with practically no pressure. By reversing the position of the cocks between the pump and the motor, the rotation of the motor can be reversed. There are two cocks for each piston, and their relative position can be changed independently, thus making as many speeds available for backward running as there are forward speeds. If all cocks are placed in the idle position, the driving shaft remains immovable. In order that variation of speed may take place smoothly, without shock, the gear is provided with a throttle valve which is opened every time the speed is changed; in this way a sudden rise of pressure in the gear is prevented and a more uniform variation of speed obtained. This valve also serves as a safety valve if the spring is set at a certain pressure. It also permits the use of the motor as an emergency brake by reversing the position of the cocks while the driving shaft continues to rotate in the same direction, thus forcing oil into the pump in a direction opposite to the rotation of the oil engine. The safety valve prevents breakages which otherwise would take place.[17]

An oil tank is provided on top of the hydraulic gear and

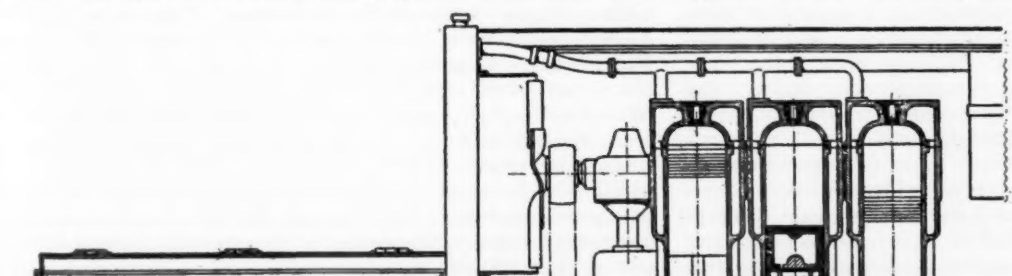

FIG. 2 DIESEL-LENTZ LOCOMOTIVE

[17] *Zeitschrift des Vereines deutscher Ingenieure*, no. 45, 1921, pp. 1160–1163.

is connected by means of pipes with the inlet chamber of the pump and the outlet chamber of the hydraulic motor. This arrangement makes it possible to keep the gear filled with oil, and prevents the foaming that would take place if air were permitted to enter and mix with the oil.

The locomotive weighs 12.12 tons and has a tractive effort of 5280 lb. The engine can run at 3 different speeds—2.5, 5.0, and 7.5 m.p.h., and pulls on a level a train of 132 tons.

b The results obtained with the 30-hp. Diesel-Lentz locomotive appeared to be so satisfactory that many builders in Germany and Austria began the construction of larger locomotives. In 1923 the Grazer Maschinenfabrik, of Graz, Austria, built a 60-hp. 0-4-0 locomotive. In this a 6-cylinder, 4-cycle, air-injection Diesel engine running at speeds of from 250 to 350 r.p.m. and developing 60 hp. at 300 r.p.m. drives the pump of a Lentz gear of the same design as the one above described. The locomotive develops a tractive effort of 4850 lb. and weighs about 22 tons. The gear provides for three speeds in either direction, namely, 3.1, 6.2, and 9.3 m.p.h. Official tests were made in Austria on March 26, 27, and 28, 1924. The members of the trial committee, consisting of Dr. K. Kobes and Dr. F. Magg, both professors of Austrian technical colleges, and several representatives of the Austrian State Railways, were very enthusiastic in their statements. They lauded the locomotive as a very simple engine, not less reliable than a steam locomotive, and with wonderful maneuvering and running qualities. On account of the running of all parts of the gear in oil they believed that there would be but little wear. They attached to their report an estimate of the efficiency of the gear, which they put at 82.6 per cent.[18] They obtained this result, however, in a roundabout way, which makes this high figure very questionable. The fuel consumption and the overall thermal efficiency show, however, a saving in fuel of about 60 per cent in train service. In switching service it will be even more, due to the absence of the stand-by losses that take place in the case of a steam locomotive.

The locomotive in question was later taken to England, and in 1924 was tested on the London and North-Eastern Ry.[19] It was first assigned to switching work and it was found that the fuel cost was 0.14 cent per ton-mile with fuel oil at $8^1/_2$ pence per gallon. Later it underwent very elaborate road tests with trains of 103 tons car weight over a distance of 105 miles. The tests were very severe, the Diesel engine running at its maximum speed (350 r.p.m.). The average train speed was 13.55 m.p.h., and during a descent on a 1 per cent gradient a speed of 25 m.p.h. was attained, the locomotive being allowed to coast with the Lentz gear put into the neutral position. The cost of fuel per train ton-mile (0.00217 gal.) was found to be 0.037 cent. The performance of the locomotive was quite satisfactory in every respect. The highest rise in oil temperature was 36 deg. fahr., the maximum temperature being 108 deg. fahr. It was found, however, that the locomotive was slow in starting and speeding up, and that in this respect improvements were needed.[20]

[18] Probefahrten mit einer 60 PSe normalspurigen Grazer Diesellokomotive. *Glasers Annalen*, September, 15, 1924, pp. 148–154.

[19] Diesel Locomotive Tests on the London & North-Eastern Railway, *The Railway Engineer*, September, 1924, pp. 316–318.

[20] Ibid., p. 299.

c At the same time the German firm that built the first 30-hp. Lentz locomotive, jointly with the Maschinenbau-Gesellschaft Karlsruhe, of Karlsruhe, Germany, developed a 160-hp. Diesel-Lentz locomotive, and built three 0-4-0 locomotives of this size for the German State Railways. These were provided with a cooler for cooling the oil used in the gear, which was found necessary for Lentz gears of higher power. These locomotives have been in service on the German State Railways since the early part of 1925. They were described by W. Schumacher in an article entitled, Rohöllokomotiven mit Kompressorlosem Dieselmotor.[21]

d The Linke-Hofmann-Lauchhammer Werke A.G., a firm in Breslau, Germany, has been very active in the developing of Diesel locomotives with Lentz transmission. In 1922 this firm built a 120-hp. Diesel-Lentz 0-6-0 locomotive for its own experimental purposes. Since October, 1922, the locomotive has been doing switching work in the yards of the company. The prime mover is a three-cylinder, four-cycle, air-blast Diesel engine of conventional design that develops 120 b.hp. at 400 r.p.m. The Lentz transmission is of the same design as described above and provides for three speeds in either direction: 2.5, 5.0, and 7.5 m.p.h. Tests made between August 1 and 3, 1922, with the Lentz gear at the company's works in Breslau showed an efficiency of about 80 per cent (average 78.1 per cent) at the third speed (72 r.p.m. on the secondary shaft) and four-fifths of full power. At a lower output (about one-third of full power) the efficiency dropped to 65 per cent (the same third speed, but smaller torque). At the second speed (48 r.p.m.) and one-third output, the efficiency rose to 78 per cent. On account of the inadequacy of the Prony-brake arrangement, higher outputs could not be materialized at this speed, and no measurements were possible at the first speed (24 r.p.m.). Nevertheless, the general trend of the efficiency curves at the second and third speeds led the company to assert that the efficiencies at high torques and low speeds will undoubtedly be much higher than 80 per cent, probably 85 to 90 per cent. To the author's knowledge, however, this has never been proved. In addition to the water cooler placed on the roof, an oil cooler has been provided; further tests, though, did not show that the latter was really needed. The engine in working order weighs 32 tons and can pull 440 tons on a level yard track—about one and one-half per cent grade—and 22 tons on a 7 per cent grade at the first speed (2.5 m.p.h.). On December 13, 1922, on an official test made with a train weighing 94 tons (weight of locomotive not included) over a stretch of 22 miles consisting of 0.5 and 1.0 per cent grades with an average speed of 7.5 m.p.h. (not counting stops), the oil consumption amounted to 2.3 lb. per 100 ton-miles.

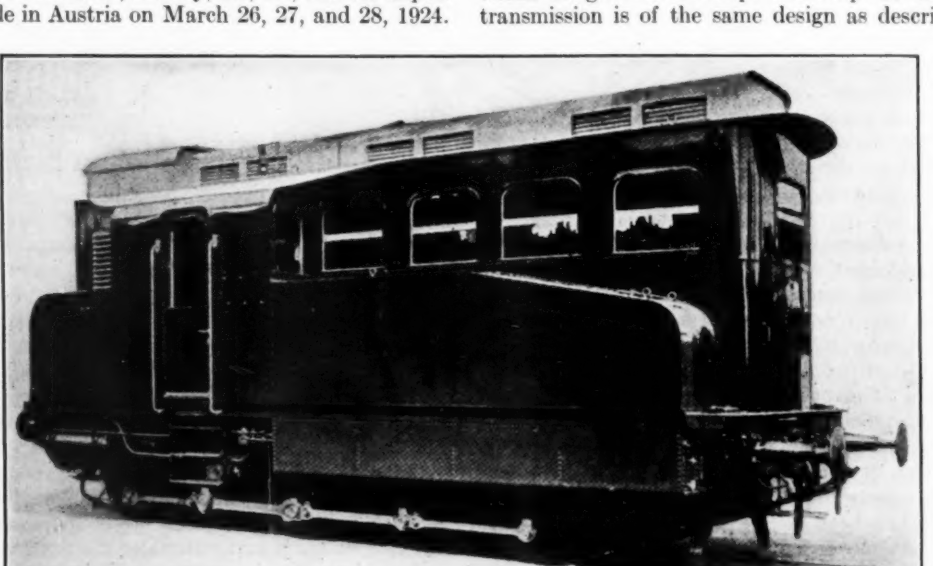

Fig. 4 400-Hp. Diesel-Lentz Locomotive

e The Linke-Hofmann Company must have been very pleased with the performance of the locomotive, because almost immediately after placing the 120-hp. locomotive in service they started building a 0-8-0 type 400-hp. Diesel-Lentz locomotive (Fig. 4).

The oil engine of this locomotive is a vertical six-cylinder, four-cycle Diesel of the marine type developing 400 b.hp. at 450 r.p.m., and special attention was paid to the use of proper material for its various parts. According to published statements the fuel consumption of this engine is very low: 0.38 to 0.42 lb. per b.hp-hr.

[21] *Zeitschrift des Vereines deutscher Ingenieure*, vol. 69, no. 19, May 9, 1925, p. 647–652.

The Lentz transmission is of the same type as the one used in the earlier locomotive. It is designed for five speeds: 6.6, 13, 21, 29, and 37 m.p.h., with a maximum tractive effort of 12,100 lb. at the lowest speed. The locomotive weighs 60.5 tons[22] and is supposed to haul 1545 tons at 13 m.p.h. on a level.

These locomotives were to be turned over early in 1925 to the German State Railways. Data as to their performance, however, have not as yet been published.

It is rumored that the same company has almost completed two more 400-hp. locomotives with Lentz gears, one with an 0-6-2 wheel arrangement, and another of the 2-4-2 type, and has also a 1000-hp. 2-8-2 locomotive under construction.

f The Motorenfabrik Deutz, an oil-engine firm of Cöln-Deutz, Germany, built jointly with Henschel & Sohn, locomotive manufacturers, of Cassel, Germany, a 0-6-0 Diesel-locomotive with Lentz gear. The prime mover is a vertical 300-hp. Diesel-engine of the "Deutz" design with airless injection, able to stand an overload to 400 b.hp. The total weight of the locomotive in working order is 43.5 tons, and the maximum tractive effort, 15,760 lb. It was exhibited in 1924 at the Exposition at Seddin, Germany, but very little is known of its design and nothing of its performance.

g Two years ago Hawthorn, Leslie & Company, an English firm, contemplated building a 300-hp. gear. Their design differed from that of the Lentz gear in that the vane pump was replaced by a multi-cylinder piston pump with variable stroke, thus permitting an infinite variation of speed. Nothing has been heard of the gear of late, and it is not known even whether it has actually been built.

h At the time when the Lentz transmission was being developed in Germany, a 0-4-0 150-hp. switching locomotive was built in Canada with the Universal hydraulic transmission developed by the Universal Engineering Corporation in Montreal. This transmission is also known as the Williams-Janney or Waterbury gear. The two parts of the transmission were separated, the primary part—the pump—being attached to the prime mover, and the secondary—the motors—acting directly on the driving wheels. The pump and the motors were connected by pressure and suction pipes, the whole arrangement resembling very much an oil-electric locomotive with motors directly attached to driving axles. The locomotive exerted a tractive effort of 12,000 lb. at starting and 3000 lb. at 12.5 m.p.h. The gear permits an infinite change of speed from zero to maximum. The locomotive weighs only 26.5 tons, this mostly on account of the prime mover being a gasoline engine of the six-cylinder Ricardo type. Tests made at the Montreal plant of the Canadian Car and Foundry Company showed that 645 tons could be readily hauled on level track. On one trial the locomotive took three cars weighing 150 tons up a four per cent grade, stopping at the steepest point and starting again under full load without difficulty. This means that the locomotive developed a rail tractive effort of at least 15,200 lb. The efficiency of this type is claimed to range between 68 per cent at a quarter normal speed to 82 per cent at full speed.[23]

The Universal Engineering Corporation has applied the variable-speed gear to a passenger rail car which has been in service on the N. Y., N. H. & H. Railroad for the last two years.

g A similar locomotive with a 75-hp. Diesel engine and Williams-Janney transmission was built some years ago by Vickers in England, and has been since in continuous service doing switching work in the Vickers plant at Barrow-in-Furness. It has a 0-8-0 wheel arrangement and two hydraulic motors acting on two jackshafts placed at the front and rear ends of the locomotive. The jackshafts are coupled to the drivers by means of connecting rods. No duplicates, however, have ever been built.

[22] 400 hp. Diesel Locomotive. *The Railway Gazette*, January 16, 1925, p. 76.

[23] Gasoline Switching Locomotive with Hydraulic Gear. *Railway Mechanical Engineer*, September, 1922, pp. 503–506.

h At the Exhibition in Seddin, Germany, in 1924, the Berliner Maschinenbau A.G. (vormals L. Schwartzkopff), of Berlin, exhibited a 0-4-0 Diesel locomotive with an oil transmission of a new design known as the Huwiler gear (Fig. 5). This latter consists of a hydraulic pump and motor, both of the vane type, similar to the Lentz gear but differing from it in that the pump delivers an infinitely variable quantity of oil to the motor, thus permitting an infinite variation in speed. This is obtained in the following way: Bushing 4 with extensions fits into the pump piston 1 and into the space between vanes 2, and can be displaced longitudinally between the vanes so as to release longer or shorter vane working surfaces. The bushing with extensions rotates together with the pump piston and vanes, but the displacement of the former is controlled by an outside fixed wheel. The pump and motor are built in two separate units connected by pipes, but they can be built in one unit with axes at 90 deg. similar to the Lentz arrangement.

The prime mover is a six-cylinder air-blast-injection Diesel engine developing 200 hp. at 440 r.p.m. The cooler, provided with a fan, is located on the roof of the car.

The locomotive had been completed just before the opening of the exhibition. Since its close in October, 1924, the locomotive has been undergoing tests, the results of which have not yet been given out.

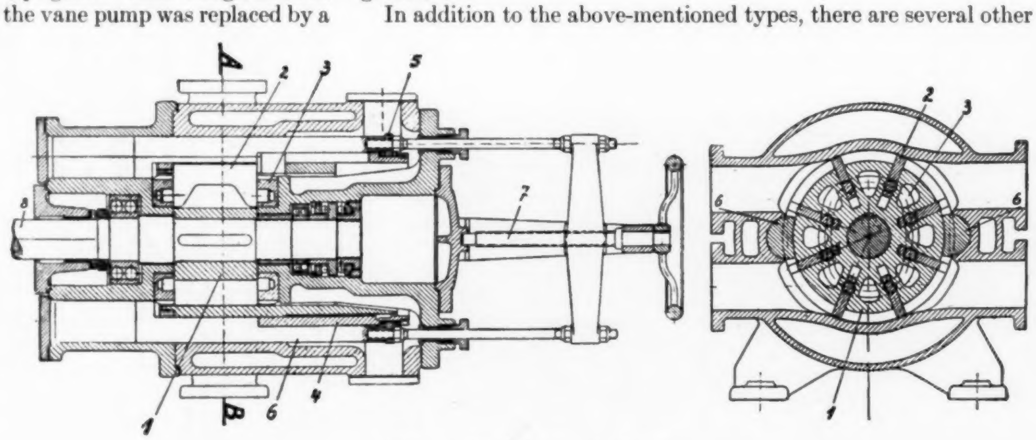

Fig. 5 The Huwiler Gear

In addition to the above-mentioned types, there are several other hydraulic transmissions, such as the Hele-Shaw gear, the Naeder drive,[24] and the Lauff-Thoma[25] transmission, which have been tried with some success on small gasoline or kerosene locomotives, rail cars, and automobiles. Primarily designed for slow and occasional work, such as ship steering, rotation of gun turrets on ships, and operating machine tools, they were later proposed for light traction work but with much less success. The Hele-Shaw gear seems to have been favored more than the others, and in 1913 it was applied to a rail car built in England for Canada, and later to several small switching locomotives built in France. The transmission proved to be very flexible, and the control and maneuvering very easy and simple, but no further progress was made in its application to locomotives. The efficiency was reported to be in the neighborhood of 75 per cent,[26] but detailed figures are not available. F. L. Martineau in his paper, Hydraulic Transmission, read in 1917 before the Institution of Automobile Engineers in London, gave efficiencies for a Hele-Shaw transmission applied to an automobile ranging, for full power, from 76 to 87 per cent. On the basis of a study of the design which had been made with the Hele-Shaw transmission, he drew a curve of possible efficiencies varying from 80 to 96 per cent at a speed-ratio range of one-sixth to full, and predicted that "soon after the war is ended it will be possible to produce a transmission showing even better efficiencies,"[27] but thus far these hopes have not been materialized.

The difficulty with hydraulic transmission seems to lie in the low efficiency resulting from the heating of the oil, which, once

[24] Application du Moteur a Hydrocarbures, by M. E. Brillié. *Revue Générale des Chemins de Fer*, April, 1923, pp. 302–305.

[25] *Hanomag Nachrichten*, vol. 12, no. 140, June 1925, pp. 94–95.

[26] Application du Moteur a Hydrocarbures, by M. E. Brillié, *Revue Générale de Chemins de Fer*, April 1923, p. 305.

[27] Proceedings of the Institution of Automobile Engineers, 1917, p. 237.

started, has a tendency to increase its temperature very rapidly. It seems that the presence of air in the oil affects very materially this rise in temperature, and that some transmissions are more likely to absorb air when running than others. Lentz, for instance, claims that he has entirely overcome this difficulty. This may be due to the low pressures which he employs—about 50 to 150 lb. per sq. in. at full speed and 400 to 500 lb. per sq. in. at starting, while others use pressures of from 400 to 600, and 1200 to 1500 lb. per sq. in., respectively.

The oil pressure has a great deal to do with the efficiency. The latter depends upon the mechanical friction losses of the mechanisms of the transmission (pistons, shafts, bearings, etc.), the hydraulic friction losses of oil in the pump and motor, similar losses of oil in the conduits (passages and pipes), and leakage of oil in the pump and motor between moving and stationary parts (between pistons and cylinders, or vanes and drums, etc.). The first—the mechanical friction losses—do not depend directly upon the oil pressure but upon torque and speed, and assuming that the power and speeds of the primary and secondary shafts (oil engine and driving wheels) are given, the mechanical friction losses do not vary materially with the type of transmission employed. The second and third—hydraulic friction losses—vary directly with the velocity of fluid in cylinders, passages, and pipes, which velocities vary inversely with the pressure. It is therefore better, as far as these losses are concerned, to work with high pressures. The fourth loss, however—leakage of oil between moving and stationary parts of the pump and motor—depends directly upon the pressure, and as far as leakage is concerned it is preferable to employ low pressures. A good design of a hydraulic gear must therefore represent a proper compromise between these conflicting influences. The Hele-Shaw transmission, or the Waterbury variable-speed gear, which are built in the form of separate pump and motors, connected by long pipes, should therefore employ high pressures and small quantities of oil, with correspondingly low velocities. High pressures, on the other hand, might cause great leakage losses. In order to keep these losses as low as possible, the cylinder-and-piston type of design has been resorted to instead of the simpler vane type. The Lentz gear, however, which is built as a simple unit with very short passages, may well afford to employ low pressures and the vane-type pump and motor. Lentz's gear thus gets the advantages of the simple-vane-type design without suffering greatly from leakage losses on account of the limitation of pressure. To these features of his design must be attributed the comparative success which it has had in Europe.

It must be remembered, however, that the low-pressure feature of the Lentz gear has its disadvantages. It requires a larger quantity of working fluid and a corresponding increase in size. Five to six hundred horsepower seems to be the limit for the size of low-pressure gears permitted by the distance between locomotive frames.

3—Pneumatic Transmission

The idea of pneumatic (air) transmission is probably one of the first types which occurred to those interested in Diesel-locomotive design. As far back as 1909, V. A. Stuckenberg, general manager of the Tashkent Railroad in Russia, suggested rebuilding steam locomotives in the following way: to replace the tender by a unit carrying a Diesel engine and compressor, to use the boiler as a compressed-air storage tank, and to let the air work in the existing locomotive cylinders in the same way as steam. The project was not considered at that time practicable, and the idea was abandoned.

About the same time James Dunlop, of Glasgow, Scotland, came out with a similar proposition. A design of a 1000-hp. locomotive was worked out and published, and it was rumored that a locomotive of this type had been built. The design embodied a double-ended 4-6-4 locomotive with a six-cylinder Diesel-compressor aggregate and two two-cylinder air engines acting on the middle driving axle with opposed cranks, the air pistons moving thus in opposite directions in order to insure a perfect balancing of the locomotive. Most probably the engine was never built, as nothing has been heard of it, although rumors to the contrary were for some time in circulation. No mention, however, is made of this locomotive in Mr. Dunlop's recent paper read on December 16, 1924, before the Institution of Engineers and Shipbuilders in Scotland on the subject of internal-combustion locomotives.

However, air transmission as suggested by Stuckenberg and Dunlop could hardly offer promising results on account of the low efficiency of air motors and of the cooling of the air during expansion, which latter would result in lubrication and other difficulties. Schelest in his book on Diesel locomotives calculated that the overall efficiency of a Diesel locomotive with air transmission would range between 13.4 and 15.3 per cent.[28] While this is almost twice the efficiency of a steam locomotive, the high first cost of such a locomotive, probably from 3 to 3.5 times that of a steam locomotive, would render the proposition impracticable, and explains why the building of a Diesel locomotive with ordinary air transmission was never seriously attempted.

a Nevertheless the Maschinenfabrik Esslingen, the German locomotive firm that built the 1000-hp. Diesel-electric locomotive for Russia, is now building a 1200-hp. locomotive with air transmission (Fig. 6). The system differs, however, from the one mentioned above in that the compressed air is heated on its way to the locomotive cylinders by the exhaust gases of the oil engine. Dr. Geiger, one of the leading engineers of the Maschinenfabrik Augsburg-Nürnberg (M.A.N.) in Augsburg, who in 1918 suggested this improvement over the Stuckenberg-Dunlop scheme, estimates that 58.5 per cent of heat contained in the oil-engine exhaust gases, which otherwise would be lost, can be recovered in the heated compressed air. The overall thermal efficiency he thus computes at 26[illegible] per cent.[29] The design consists of a six-cylinder submarine type M.A.N. engine which drives a compressor. Air compressed to about 110 to 125 lb. per sq. in. and thus already heated to about 500 deg. fahr. is further heated by the exhaust gases to approximately 700 deg. fahr. The two cylinders which are placed in front of the locomotive, the valve, valve-motion rods, and other running parts are of the well-known locomotive type, as are also the frames,

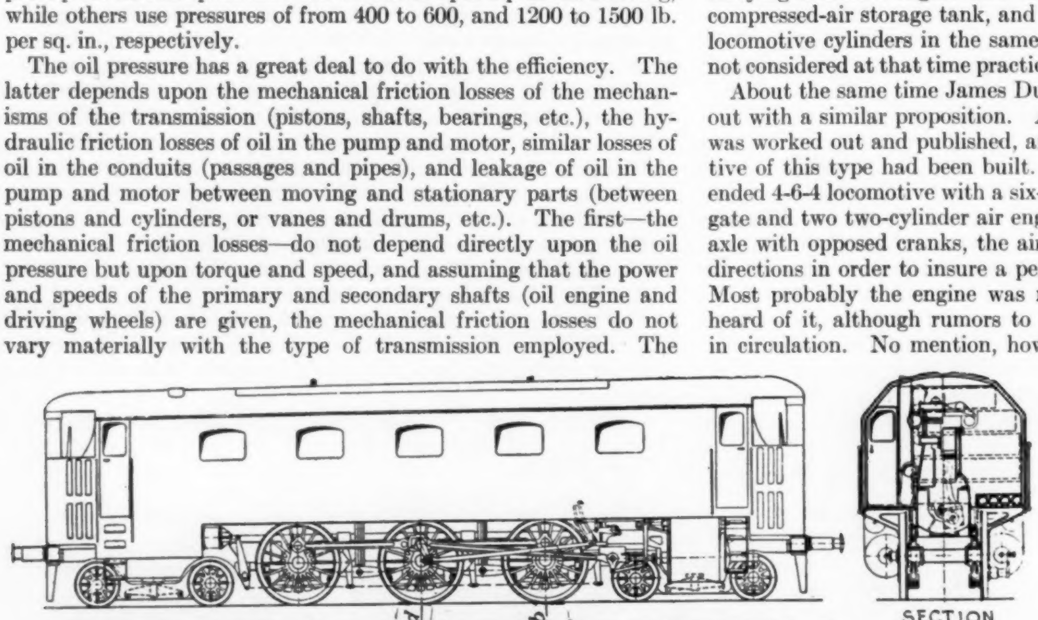

Fig. 6 1200-Hp. Diesel Locomotive with Air Transmission

[28] Wirtschaftliche Lokomotiven, by A. Schelest, p. 57; published by Deuticke in Leipsic in 1923.

[29] Dieselmotor und Kraftübertragung für Grossoellokomotiven, by Dr. J. Geiger, *Zeitschrift des Vereines deutscher Ingenieure*, May 9, 1925, pp. 642–646. See also *Oil Engine Power*, May, 1925, diagram on p. 308. Note that the "exhaust losses" figure (11 per cent) is erroneously printed in the space of "exhaust gas heat."

boxes, springs, trucks, wheels, etc. The engine bedplate fits into the locomotive frame, which is of the bar type; the wheel arrangement is 4-6-4. Special tests preceded the working out of the design. A small compressed-air model had run in 1919, and later, in 1923, a one-cylinder full-size installation had been tested. The preliminary test results served as a basis for the present design. In addition these tests dissipated all apprehension of danger from lubricating-oil ignition. Designers were afraid that lubricating-oil vapor coming in contact with heated air might ignite and cause an explosion, but the tests convinced them that their fears were unfounded. Although the lubrication was ample, no traces of any lubricating-oil deposits were found during the tests. Occasionally electric sparks were allowed to pass through the piping, but no explosion ever resulted. It must be rememberd, however, that special precautions were taken, that nowhere could lubricating oil accumulate, and that only pure air entirely free from oil was used for the cycle. Whether similar precautions could always be taken in the future on actual locomotives is not entirely certain. Dr. Geiger is of the opinion that the success of air transmission on main-line locomotives depends upon the possibility of developing an efficient and powerful fast-running compressor, and that until this has been done, it would be premature to become enthusiastic about the possibilities of compressed-air transmission.

The idea of preheating air in locomotives is not quite new. It was suggested by Borsig of Berlin for two-stage compressed-air locomotives, and the H. K. Porter Company, of Pittsburgh, Pa., devised a very ingenious scheme for utilizing the heat in the atmosphere for heating air cooled during the first-stage expansion.[30]

4—Steam Transmission

Instead of air, steam working in a closed circuit was suggested several years ago by Cristiani, of Milan, Italy. In his design, steam from a high-pressure container is superheated by the exhaust gases of a Diesel engine and expanded in ordinary steam cylinders; it is then expelled at 25 to 30 lb. per sq. in. into a low-pressure receiver which is cooled by atmospheric air driven by a fan. A steam compressor then draws the cooled steam from the receiver, compresses it to approximately 180 lb. per sq. in. and rejects it to the high-pressure container, after which it is again superheated, expanded, etc. The steam compressor is directly driven by a Diesel engine, and the total output of the latter is transformed into compressed-steam energy which is utilized in the locomotive's steam cylinders.

The steam needed for the process is first obtained from a small boiler, which later serves to replenish the amount lost through leakage, condensation, etc.

Cristiani, however, does not anticipate any condensation, as he thinks that the steam will always be superheated. He estimates the efficiency of the transmission to be 70 per cent, giving a total overall efficiency of 23 per cent for the Diesel locomotive. He thinks that the design of the steam-transmission parts (compressor, superheater, etc.) is simpler and the construction of these parts cheaper than is the case with any other form of transmission.

a In 1923 Cristiani started the construction of a 900-hp. locomotive for the Northern Railway of Milan. The locomotive is of the 0-8-0 type and is driven by two six-cylinder 450-hp. two-cycle Diesel engines at 500 r.p.m. There are two steam compressors driven separately by each of the two Diesel engines. No information as to the progress of the work is available.

5—Aero-Steam Transmission

a The expansion of air in working cylinders is usually accompanied by a rapid drop in temperature. This was the stumbling block in the way of the first air-transmission projects. An Italian engineer, Fausto Zarlatti, thought that he might be able to overcome this difficulty by mixing the air with steam and thus keep the air warm during expansion due to the smaller fluctuation in temperature of the expanding steam. He suggested, therefore, an aero-steam transmission, and even went so far as to rebuild a small six-wheel locomotive which he received from the Northern Railway of Rome. A six-cylinder gasoline engine of approximately 70 hp. drove an Ingersoll-Rand air compressor. The engine and compressor were mounted on the tender, and compressed air was stored in the old locomotive boiler partly filled with water. The air preheated by compression before entering the working cylinders, must have passed through the column of water in the boiler and thus been saturated with vapor. In addition, use was made of the heat contained in the exhaust gases of the gasoline engine; these gases passed through the boiler and generated a certain amount of steam. The mixture of air and steam was admitted to the cylinders by means of the existing throttle and reverse lever. The locomotive with its tender thus reconstructed weighed 42 tons.

b James Dunlop, of Glasgow, who back in 1909 proposed to employ air transmission, came out lately with a new design of a main-line 1100-hp. locomotive with an aero-steam transmission. The idea is the same as that embodied in the Zarlatti locomotive, but the design is worked out on sound lines and is of great interest. The prime mover is a six-cylinder, two-cycle, airless-injection oil engine of special design with air-compressing cylinders placed on the top of working cylinders of an annular shape. Steam of 200 lb. pressure, generated in a boiler heated by the exhaust gases of the oil-engine cylinders, is superheated by the compressed air, with which it mixes; this is supposed to result from the fact that compressed air at 200 lb. pressure is over 200 deg. fahr. higher in temperature than steam at 200 lb. pressure.[31] The water space of the boiler is connected with the water-cooling jackets of the oil engine, similar to the arrangement used in the Still engine.

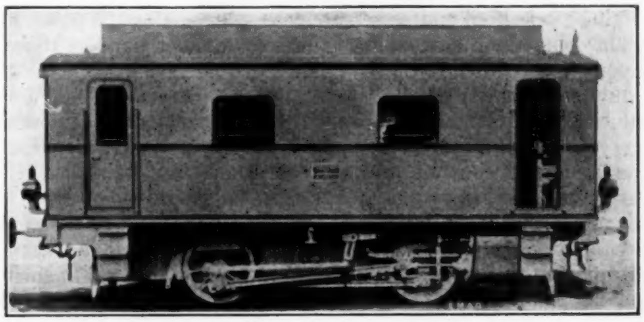

Fig. 7 Diesel Locomotive with Exhaust-Gas Transmission

This system, as compared with the heated-air transmission, has this advantage that the heat contained in the oil-engine exhaust gases is transmitted to a better absorbing medium—water and steam—than compressed air already heated by compression, and that the excess heat contained in compressed air is utilized for superheating steam by the direct mixing of air and steam. Dunlop further makes the assertion that "hot compressed air entering the traction cylinders along with the steam prevents initial condensation, and also prevents contact of the steam particles, so that they do not coalesce as the temperature in the cylinders falls during expansion, with the result that the steam in the mixture is about 40 per cent more effective than it would be if no air were mixed with it."[32]

Dunlop bases his calculation of the *apparent* transmission efficiency on the assumption of 40 per cent improvement, and obtains 102.47 per cent,[33] a figure which is not impossible.[34] Nevertheless, this would mean a gain of 46.5 per cent over the 70 per cent ordinary air-transmission efficiency, whereas the Still oil engine, which also makes use of the heat contained in the exhaust gases and cooling water, shows an improvement of only 16 per cent. Assuming that the aero-steam transmission would probably give the same gain, one may expect to get an efficiency of 81 per cent.

[30] See *Zeitschrift des Vereines deutscher Ingenieure*, 1911, pp. 611 and 1043; also 1912, p. 78 (Professor Nicolson's tests).

[31] Internal-Combustion Locomotives, by James Dunlop. Published by the Institution of Engineers and Shipbuilders in Scotland, Glasgow, 1924, p. 11.

[32] Ibid., p. 11.

[33] Ibid., p. 19.

[34] The use of the word "apparent" is made on account of adding to the work obtained from the compressed air, the extra work rendered by steam generated from sources outside the Diesel-engine cylinders. Since the energy usually wasted with the exhaust and cooling water represents 165 per cent of that obtained from the Diesel-engine cylinders, a recuperation of only 19.7 per cent of the losses, if it were possible, would render a 70 per cent air-transmission efficiency into 102.47 per cent.

6—Exhaust-Gas Transmission

With compressed-air transmission there is always danger of lubricating-oil ignition, and special precautions must be taken to avoid this. In order to eliminate the slightest possibility of an oil explosion, it was suggested that an inert gas be used instead of air. In the case of an oil-engine locomotive the most convenient gas to use would be the exhaust of the engine itself.

a Several years ago the Waggon und Maschinenbau A.G. Görlitz, of Görlitz, Germany, patented a system of transmission for oil-engine locomotives by which the oil-engine exhaust gases are compressed and expanded in ordinary locomotive cylinders. The same firm, jointly with Berliner Maschinenbau A.G., vormals L. Schwartzkopff, of Berlin, Germany, actually built a 0-4-0 locomotive (Fig. 7) embodying this principle which was shown in 1924 at the Exhibition in Seddin. The prime mover of the locomotive which drives the exhaust-gas compressor is a 220-hp. Diesel engine running at 500 r.p.m. The exhaust gases of the engine are first cooled, then compressed to about 115–140 lb. per sq. in., and cooled at the same time, and only afterward, when the cooling is finished, are the compressed gases heated to approximately 660 deg. fahr. by the exhaust gases on their way to the cooler. The object of cooling the gases before and during the compression is to keep the size of the compressor and the power absorbed by compression as low as possible.[35]

The overall thermal efficiency of the engine is claimed to be 24 per cent, but whether the engine has ever been run and tested and what results were obtained, if any, is not known.

(To be continued.)

[35] Beschreibung der von Berliner Maschinenfabrik A.G. während der Eisenbahntechnischen Tagung in Seddin ausgestellten Lokomotiven, pp. 17–18.

Selecting a Power and Heat Supply for Industrial Plants

In a paper bearing the above title which was presented at the Providence Meeting of the A.S.M.E. on May 4, Marcus K. Bryan[1] discussed a basis upon which schemes used to supply the heat and power demands of industrial might be compared when making a selection, and presented curves illustrating the power and steam demands of a number of different industries. Mr. Bryan's paper was published in the June issue, p. 567.

In discussing Mr. Bryan's paper, John A. Stevens[2] stressed the value of a careful analysis, which meant knowing exactly where every pound of steam went, under what pressure, and for what it was used—and such an analysis took a long time to make. If it was found cheaper to put in a turbine, it should be done. If it was found cheaper to use public-utility power, that was the power to employ. If a mill owned water power, it could use it and then buy public-utility power. Engineering was nothing but financing, and no plant was an ideal one that did not earn money. The thing to do was to analyze the plant and have it make all the manufacturing-process and heating steam when it could, and make it by by-product machinery. If a mill owned water power, it should use it, storing sometimes when it was using by-product steam.

H. M. Burke[3] said that he did not agree with the author that every case was a special one and required special treatment, and that there was no standard to go by. There was a standard by which a great many plant engineers were guided and it was usually set up by the treasurer of the company and was usually about half what was really needed in what he considered as a non-producing unit of the plant.

Mr. Burke told of a study of exhaust steam that had led to the purchase of two specially made turbines of the extraction type that were quite different in design from the usual bleeder turbine. After exhausting every practical and reasonable method for consuming the exhaust steam from his company's prime movers, there had been occasionally times when it was impossible to prevent wasting through the exhaust head.

It had not been considered advisable to install a condenser, so in designing these turbines it had been decided to make the design hinge on the exhaust-steam demand. This condition satisfied, an automatic regulation on the bleeder valve was designed, extracting 80-lb. steam from the first stage of these nine-stage pure-impulse Rateau-type turbines with practically no sacrifice of efficiency—just the reverse of the usual design.

These turbines were rather unique in that they were designed for 250-volt direct current, and were geared direct to generators by 8 to 1 double helical reduction gearing. The steam pressure was 200 lb. gage, 100 deg. fahr. superheat, and for any desired value between 10 and 15 lb. gage back pressure.

Mr. Burke disagreed with Mr. Stevens' remarks concerning finance, which was rather an illusive word. Engineering and finance might be synonymous. There were many brands of finance, but one of the hardest brands to meet was the one that answered an argument with "I know your argument is based on sound engineering principles, but we can't spend all the money you require. You must do with less, you must do the expedient."

Contractors, machine builders and engineers had all fostered the overdevelopment of industry through selfish interest with utter disregard of the business as a whole. Even now, in this hectic time for cotton mills, the same process was going on regardless of the laws of supply and demand with only one thought in mind, namely, produce cheaper than the other man.

It was time for the engineer to look to his code of ethics, to give the benefit of his special training, to use his analytical mind, and take a broader vision of the industry and help get it back to the old-time cash basis.

Alfred Vaksdal[4] said that the consulting engineer carried a tremendous responsibility in this field, of eliminating wasteful methods of generation and use of power. But unfortunately a good many plant engineers looked upon the consulting engineer as one that found fault with everything. A plant engineer should not consider the consulting engineer infallible, and the management should not accept his proposition without question. Consequently the plant engineer should make his own investigation, assemble complete data, and lay out a proposed plan with estimates of costs and savings so that the conclusion could be drawn up in coöperation with the consulting engineer.

A few years ago his company's boilers could not supply the demand, and a request for more boilers and another condensing generating unit had been made. With the necessary building extension this would have required an expenditure of something like $300,000. Further study, however, disclosed the fact that the power house was plenty large enough: it was only a matter of using the equipment in a more efficient way. Accordingly a 500-kw. non-condensing unit which was standing idle as a reserve was put in operation, and the exhaust steam thus derived was substituted for the live steam previously used in the heating system, and the balance absorbed by a mixed-flow turbine.

One of the branch plants located about 1300 ft. from the main power house discontinued its boilers, and pipe lines were installed supplying steam and air from the main plant for operation. The branch plant's steam-driven air compressor was later put in operation, discharging the exhaust into the heating system instead of live steam from the power house, which had been used previous to starting the compressor, and in doing that more air was supplied to the branch plant than it could use, without increasing the steam supply in the least. With this and a few corrections in the distributing

[1] Mechanical Engineer, Chas. T. Main. Assoc-Mem. A.S.M.E.
[2] Consulting Engineer, Lowell, Mass., Mem. A.S.M.E.
[3] Plant Engineer, Mt. Hope Finishing Co., North Dighton, Mass. Mem. A.S.M.E.
[4] Plant Engineer, Corning Glass Works, Corning, N. Y. Mem. A.S.M.E.

system the company was able to shut down one or more boilers in the main plant, which gave it the needed spare. Thus for a nominal cost the expenditure of $300,000 was put off for a few years at least, if not longer, and the following results had been obtained with equipment which it was figured had been outgrown three years ago.

The boiler efficiency was increased from 64 to 78 per cent; steam consumption for electricity decreased from 30 lb. per kw. to 14 lb.; steam consumption for compressed air decreased from 55 lb. per 1000 cu. ft. to 40 lb. The compressed-air demand had since doubled, the electric load tripled, and the radiation in the buildings had increased 60 per cent. Unit costs were as follows:

Unit cost for coal per 1000 lb. of steam net	$0.235
Unit cost without overhead per 1000 lb.	0.316
Unit cost including overhead per 1000 lb.	0.450
Unit cost of heating per sq. ft. of radiation per year	0.725
Unit cost for coal per kw-hr.	0.0034
Unit cost without overhead per kw-hr. generated	0.0066
Unit cost including overhead per kw-hr. generated	0.0129
Unit cost of coal per 1000 cu. ft. of free air	0.099
Unit cost of coal per 1000 cu. ft. of free air without overhead	0.019
Unit cost per 1000 cu. ft. of free air, including overhead	0.029
Unit cost for coal per 1000 gal. water pumped	0.0056
Unit cost without overhead per 1000 gal. water pumped	0.0132
Unit cost including overhead per 1000 gal. water pumped	0.0196

Francis A. Willett[5] said that in an investigation where the success or failure depended on the quantity of the process steam used, a careful study of this process steam was of vital importance. The quantity of exhaust steam required for manufacturing purposes played a large factor in whether it was cheaper to make the power or to purchase it.

To take a plant as it was found and base all conclusions on the present operating conditions would give a correct solution to these conditions, but a real investigation should go a step further to find out if the steam was being used to the best possible advantage. This investigation should take into account the temperature requirements of each process requiring heat to determine the most economical steam pressure to be used. This might even require an investigation of the process itself to determine whether it could be divided into a high-temperature and a low-temperature component in order to increase the exhaust-steam load. Working along these lines, many high-pressure steam consumers might be changed over to low pressure with no slowing up in the process. All this was with the idea of increasing the exhaust-steam requirements to balance the steam produced in developing the power consumed.

The various arguments against the use of exhaust steam, such as dilution of liquid due to more steam being required, oil in steam, and slowing up of operation, could all be taken care of by proper arrangement of the work and size of the equipment.

F. M. Gunby[6] said that it was necessary in connection with the use of non-condensing or partially non-condensing turbines to make sure that the demands for power and for steam coincided in times in such manner that the turbine exhaust would not be wasted for any substantial length of time. Wasting the exhaust from a non-condensing turbine for only a small fraction of the operating time might wipe out all of the savings that had been built up during the rest of the operating period.

Fixed charges of interest, depreciation, insurance, and taxes were an important factor in determining on the advisability of making installations of this character. Very few industrial plants ran more than 7200 hours a year, and many of them ran only about 2400 hours. Fixed charges applied on a basis of about 8760 hours a year. In many cases of plants operating a small number of hours a year, fancy operating savings had been wiped out by fixed charges. Mr. Gunby mentioned this because frequently this matter of fixed charges was overlooked, or underrated. There were many places, he said, where a net saving of considerable proportion could be made by installing power units to obtain power from steam required for process work, and consideration should be given to all of the conditions surrounding these installations in determining on their advisability.

H. Anderson[7] contributed a written discussion of the paper that was received after the meeting. In this he said that if the costs of boiler and turbine plants given in Table 1 were reduced to unit figures, the following values would be obtained per installed kilowatt: 1000 kw., $178; 2000 kw., $152; 3000 kw., $130; 5000 kw., $133. This did not seem consistent as, everything else being equal, the unit cost should decrease with an increase in plant size. Using a unit cost of $110 per installed kilowatt, the total investment for the 5000-kw. plant would be about $550,000, and using the same percentage as used by the author, or $12^1/_2$ per cent, a yearly fixed charge of $68,750 would be obtained. The total yearly power and heat cost would therefore be $196,050, which was less than the purchased power cost.

In general, an industry having a low load factor would not be able to generate its own power as cheaply as it could purchase power, as the fixed charges would form too big a percentage of the power costs.

This should not, however, be taken as a hard-and-fast rule, as each different industry had to be judged on its own merits. The use of higher steam pressures, for example, would in many cases reduce the power costs materially in the industrial plant.

The author, in closing, said that Mr. Burke's remarks regarding overdevelopment of industry fostered by machinery builders, contractors, and engineers through their selfish interest seemed extraneous unless it was to be inferred from them that a fair comparison of schemes was needed as a deterrent to this influence. It was not the engineer's province to decide questions of management and finance. He did not have the facts for such decisions. It was, however, in the author's opinion, the engineer's duty to place before the management a complete statement of the problem and its solutions in a form which would show the relative financial advantages of the practical engineering solutions. He had pointed out in the paper a basis upon which schemes for supplying power and heat to industrial properties could be compared for the selection of one of them, this basis being the savings resulting from the schemes and the earnings which would be returned on the investments, all modified by judgment of reliability, flexibility for growth, and sustained use.

It was true that many managements considered the power plant as a non-productive unit, but every industry must have power and heat, and, generally speaking, the conditions of industrial plants differed sufficiently so that every case needed a measure of special treatment to determine the most desirable source of its power, and heat supply, for there was some scheme of supplying these services which is most advantageous. The similarity between plants would suggest the use of certain schemes and the impracticability of others, with the result that one's experience and judgment eliminated many possibilities and centered study upon a few schemes probably worth while, and these should be compared in detail.

Continuing, the author said that there were numerous cases in his experience in the study of existing plants where possible economies, which were now impractical, could have been realized and would have been recognized and appreciated and developed by a more careful study of possibilities at the inception of the project.

A careful study of an industrial plant would cover the points brought out by Messrs. Vaksdal and Willett, and points of this nature were of importance.

The unit costs worked out by Mr. Anderson decreased consistently, as he pointed out, from 1000 to 3000 kw., and then the 5000-kw.-plant cost increased. As these plants had been set up this change in unit prices was entirely correct and was principally caused by a change in the type of plant. The plants below 5000 kw. were hand-fired plants with single-story boiler houses, while the 5000-kw. plant was an underfeed-stoker-fired plant. It was to be remembered that these plants operated 8 hours per day, or 2400 hours per year. The figure of $110 per kilowatt was, in the author's opinion, not enough to build a 500-kw. stoker-fired plant of the economy shown by the operating costs given in the table.

In a report by the Prime Movers Committee of the N.E.L.A., the ash-disposal methods of several public utilities are discussed. An interesting development is the use of cinders in building blocks, which are gaining increased favor among contractors for use as hollow tile and for foundation work in smaller buildings. They are light in weight, fireproof, moisture proof and sufficiently soft to permit direct nailing. This latter characteristic eliminates the use of grounds ordinarily employed in brick or tile construction. *Power*, June 29, 1926, p. 1026.

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[5] Tyrrell & Willett, Engineers and Contractors, Pawtucket, R. I. Assoc-Mem. A.S.M.E.

[6] Engineering Manager, Chas. T. Main, Boston, Mass. Mem. A.S.M.E.

[7] General Engineer, Westinghouse Electric & Mfg. Co., Philadelphia, Pa. Assoc-Mem. A.S.M.E.

The Specification and Control of Mechanical Springs

By JOSEPH KAYE WOOD,[1] NEW YORK, N. Y.

This paper is another of a series on the general subject of springs which the author has presented recently, and deals with the subject of specifications for the manufacture of springs and for spring materials. A list of the available specifications for heavy springs is given and the features of these specifications are tabulated. In the absence of specifications for small springs the author discusses the outline for such specifications and illustrates his method by a hypothetical case. He introduces the idea of a "load-deflection sector" to be used in place of a load-deflection curve, and employs the idea in framing his sample specification.

SPACE and weight limitations, finer control of operation, and higher speeds in modern machine design have given rise to the necessity of greater adequacy in specifications with little or no increase in commercial restrictions. In the case of mechanical springs there are a few specifications of long standing, but these are confined principally to the larger types of springs used in the automotive and railway industries. Considering the great amount of spring breakages in these two fields, we can say that although the present specifications are commercial and are being met in practice, they are not adequate or suitable for the intended service. However, such specifications are written as well as the present state of the spring art will permit. The arrangement of the component parts is the result of many years of practical experience, and for this reason it would be wise to refer to them when making up specifications for medium- and small-size springs. Very little publicity has been given to what few specifications there are in existence covering the latter type of springs. The usual manner of specifying such springs is by showing the essential dimensions and designation of material on the detail blueprint. It is the purpose of this paper to analyze and determine the reason for this condition, and to suggest a form of specification for constructive criticism.

Makers of springs may be divided into two general classes: first, "indirect-sale" manufacturers, or those who make springs for use in their own product, and second, "direct-sale" manufacturers, or those who make springs for direct sale to another concern requiring the springs for use in their product.

Direct-sale manufacturers may be classified further as those who supply their own raw material, and those who obtain their raw material from outside sources. The overall classification is as follows:

- Makers of mechanical springs
  - Indirect-sale
    - Automotive
    - Typewriter
    - Telephone
    - Adding machine
    - Tool machinery
    - Railway, etc.
  - Direct-sale (Spring manufacturers)
    - Supply own raw material
    - Purchase raw material

The specifications in all cases should be basically similar, the only difference being that in the indirect-sale type no legal proviso regarding inspection and rejection would be necessary, and in the direct-sale type of specification the manufacturing and commercial conditions of the average spring manufacturer would have to be considered. Another condition that should be taken into consideration is the relative knowledge of the art of spring design of the direct-sale manufacturer and his customer.

Where springs are bought from a spring manufacturer, a sample mechanism may be supplied with the blueprint, in which case the manufacturer, in his capacity as a spring specialist, will either approve the design or suggest certain changes, thereby accepting full responsibility for the performance of the delivered springs. In the case of the indirect-sale manufacturer under the present state of affairs, an extreme amount of time and money is being wasted. The procedure is somewhat as follows: The designer or draftsman may simply consult a handbook and use the first formula or table on springs that confronts his eye. Or again it may happen that either the designer or draftsman will design the spring as carefully as he knows how, putting the calculated dimensions, with or without arbitrary tolerances, on the blueprint. Usually no effort is made to determine what the commercial variations due to spring and material manufacturing methods are, nor to determine what effect these variations are likely to have on the actual operation of the spring. As a result of this indifference, if the first few samples are found to be satisfactory, mass production is launched. The product then goes into service by the thousands, but before a year has passed complaints pour in, an expensive engineering investigation is authorized, and not infrequently it is found that the springs are the cause of the trouble. Analysis may show that the particular springs which failed are those in which manufacturing and material variations were cumulative. It is surprising to know that the maximum possible range in operation, due to cumulative variations, is sometimes equal to thirty or forty per cent. Only by providing more adequate specifications can the possibility of this high percentage be eliminated and costly troubles thus avoided.

Specifications Covering Mechanical Springs

The following definition is given in the author's paper A Code of Design for Mechanical Springs: "A mechanical spring is an elastic body whose load-deflection rate and maximum safe deflection are of values suitable for mechanical use." A mechanical-spring material may be defined as follows: "A mechanical-spring material is an elastic material of the kind which, when made into bodies of a shape and size suitable for use in mechanical design, will function repeatedly and permanently as a mechanical spring."

From these definitions it follows that a mechanical spring would be needed where a difference of pull or pressure at the extremities of a given movement would be required. Since the retroactive force of springs is elastic, the pulls or pressures are usually proportional to the amount of travel, provided the proportional limit of the material is not exceeded. Elastic hysteresis will cause a slight loop in the load-deflection curve, but this is so slight that for most practical purposes it may be ignored.

The manner of application and the size and shape of the space available determine the type or shape of spring needed. Thus if rotary motion in a round or square space is desired, a spiral spring would be used. If the translatory movements are to be small in comparison with a long, narrow space, then a flat cantilever spring would be decided upon. Helical springs would be used in a long cylindrical or prismoidal space, stressed in torsion if the motion has to be translatory and stressed in flexure if the motion has to be rotary.

It is necessary to emphasize the importance of the space assigned for spring action, which during the design stage of a mechanism is frequently obtained by the process of elimination. Thus the space available for the installation of a proper spring often is inadequate; the usual complaints may follow, but due to the fact that mass production has advanced too far, the space for the spring cannot be changed. Two outstanding examples of this condition are the motor spring of a telephone dial and the helical springs on railway cars.

In general, the component parts of a spring specification are as follows:

[1] Consulting Engineer. Assoc-Mem. A.S.M.E.

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1. Title
2. Scope
3. Material
   - Refers to a spring-material specification
   - or
   - Includes the control of material
     - Process of manufacture
     - Chemical analysis
     - Method of chemical testing
     - Control of principal working heights
4. Physical properties and tests
   - Permanent-set test
   - Retest of permanent set
5. Permissible variations
6. Workmanship
7. Shipment and marking
8. Inspection
9. Rejection
10. Rehearing.

The general construction of a spring-material specification usually is in accordance with the following outline:

1. Title
2. Scope
3. Process of manufacture
4. Chemical
   - Composition
   - Ladle analysis
   - Check analysis
5. Permissible variations in gage
   - Thickness or diameter
   - Width
   - Length
6. Finish
7. Shipment and marking
8. Inspection
9. Rejection
10. Rehearing.

It is sometimes the practice where either the chemical or physical methods of testing are common to those included in several other types of specifications, to adopt a standard specification covering just that part and to make reference to it in either the spring or spring-material specification. Another practice is to supplement a spring specification by an appendix giving a description of a standard formula to be used in calculating the fiber stress.

A list of some of the most important existing specifications covering both springs and spring materials is given at the top of the following column.

Process of Manufacture

Steel is by far the best type of material for mechanical springs and is most commonly used. Spring steels are manufactured largely by the open-hearth process, although a considerable quantity is produced by the electric furnace, and a small amount by the crucible process. The above-mentioned specifications permit the use of any of these three processes.

Spring Specifications

Designation for this Paper	Title	Issued by	Designation
S-1	Specification for Helical and Elliptical Springs	Penn. R. R. System..	No. 12-H
S-2	Standard Specification for Helical Springs for Railways	American Society for Testing Materials	A61-16
S-3	Standard Specification for Elliptical Springs for Railways	American Society for Testing Materials	A62-16
S-4	Standard Specification for Elliptical Springs for Automobiles	American Society for Testing Materials	A69-18
S-5	Standard Specification for Helical Springs	American Railway Association	....
S-6	Standard Specification for Helical Springs of Chrome-Molybdenum Steel	American Railway Association	....
S-7	Elliptical Springs	American Railway Association	....

Spring Material Specifications

Designation for this Paper	Title	Issued by	Designation
SM-1	See S-1 for Carbon-steel	Penn. R. R. System..	No. 12-H
SM-2	See S-1 for Chrome-vanadium	Penn. R. R. System..	No. 12-H
SM-3	See S-1 for Silico-manganese	Penn. R. R. System..	No. 12-H
SM-4	Standard Specification for Carbon-Steel Bars for Railway Springs (with S-2 or S-3)	American Society for Testing Materials	A14-16
SM-5	Standard Specification for Carbon-Steel Bars for Railway Springs with Special Silicon (with S-2 or S-3)	American Society for Testing Materials	A68-18
SM-6	Standard Specification for Carbon-Steel Bars for Vehicle and Automobile Springs (with S-4)	American Society for Testing Materials	A58-16
SM-7	Standard Specification for Silico-Manganese Steel Bars for Automobile and Railway Springs (with S-2, S-3 or S-4)	American Society for Testing Materials	A59-16
SM-8	Standard Specification for Chrome-Vanadium-Steel Bars for Automobile and Railway Springs (with S-2, S-3 or S-4)	American Society for Testing Materials	A60-16
SM-9	Standard Specification for Spring Carbon Steel of Heavy Rolled Section	Society of Automotive Engineers	S.A.E. 1095
SM-10	Standard Specification for Spring Carbon-Steel of Light Rolled Section	Society of Automotive Engineers	S.A.E. 1080
SM-11	Standard Specification for Spring Silico-Manganese Steel of Heavy Rolled Section	Society of Automotive Engineers	S.A.E. 9260
SM-12	Standard Specification for Spring Silico-Manganese Steel of Light Rolled Section	Society of Automotive Engineers	S.A.E. 9250
SM-13	Standard Specification for Spring Chrome-Vanadium Steel	Society of Automotive Engineers	S.A.E. 6115
SM-14	Standard Specification for Spring Chrome-Vanadium Steel	Society of Automotive Engineers	S.A.E. 6150
SM-15	A. R. A. Specification for Carbon Steel Bars for Railway Springs (with S-5 and S-7)	American Railway Association	....
SM-16	See S-6 for Chrome-Molybdenum Steel..	American Railway Association	....
SM-17	Specification for Rolled or Drawn Spring Steel	U. S. Navy Dept.......	47S4d

Chemical Composition of Material

The chemical compositions of the steels referred to in the above specifications are given in Table 1. These steels, it should be remembered, are used entirely in large-size helical and elliptic springs.

TABLE 1 CHEMICAL COMPOSITION OF SPRING-STEEL MATERIAL

Specification (Designation for this paper)	Name of steel	Carbon Min.	Carbon Max.	Manganese Min.	Manganese Max.	S Max.	Phosphorus Max. Basic	Phosphorus Max. Acid	Silicon Min.	Silicon Max.	Chromium Min.	Chromium Max.	Vanadium Min.	Vanadium Max.	Molybd. Min.	Molybd. Max.
		Chemical composition, per cent														
SM-1	Carbon	0.90	1.10	....	0.50	0.05	0.05	0.05	0.25	0.50	....	....	....	....	....	....
SM-2	Chrome-vanadium	0.55	0.65	0.60	0.90	0.05	0.05	0.05	....	....	0.80	1.10	0.15	....	....	....
SM-3	Silico-manganese	0.45	0.55	0.60	0.80	0.05	0.05	0.05	1.80	2.10	....	....	....	....	....	....
SM-4 Grade A	Carbon	0.90	1.10	....	0.50	0.05	0.05	0.05	....	....	....	....	....	....	....	....
Grade B	Carbon	0.95	1.15	....	0.50	0.05	0.05	0.05	....	....	....	....	....	....	....	....
SM-5 Grade A	Carbon with special Silicon	0.90	1.10	....	0.50	0.05	0.05	0.05	0.25	0.50	....	....	....	....	....	....
Grade B	Carbon with special Silicon	0.95	1.15	....	0.50	0.05	0.05	0.05	0.25	0.50	....	....	....	....	....	....
SM-6 Grade A	Carbon	0.85	1.05	0.25	0.50	0.05	0.05	0.05	....	....	....	....	....	....	....	....
Grade B	Carbon	0.90	1.05	0.25	0.50	0.05	0.04	0.05	....	....	....	....	....	....	....	....
SM-7 Grade A	Silico-manganese	0.45	0.55	0.60	0.80	0.045	0.045	0.05	1.80	2.10	....	....	....	....	....	....
Grade B	Silico-manganese	0.55	0.65	0.50	0.70	0.045	0.045	0.05	1.50	1.80	....	....	....	....	....	....
SM-8 Grade A	Chrome-vanadium	0.45	0.55	0.50	0.80	0.05	0.04	0.05	....	....	0.80	1.10	0.15	....	....	....
Grade B	Chrome-vanadium	0.55	0.65	0.60	0.90	0.05	0.04	0.05	....	....	0.80	1.10	0.15	....	....	....
SM-9	Carbon	0.90	1.05	0.25	0.50	0.05	0.04	0.04	....	....	....	....	....	....	....	....
SM-10	Carbon	0.70	0.90	0.25	0.50	0.04	0.04	0.04	....	....	....	....	....	....	....	....
SM-11	Silico-manganese	0.55	0.65	0.50	0.70	0.045	0.045	0.045	1.50	1.80	....	....	....	....	....	....
SM-12	Silico-manganese	0.45	0.55	0.60	0.80	0.045	0.045	0.045	1.80	2.10	....	....	....	....	....	....
SM-13	Chrome-vanadium	0.10	0.20	0.50	0.80	0.04	0.04	0.04	....	....	0.80	1.10	0.18	....	....	....
SM-14	Chrome-vanadium	0.45	0.55	0.50	0.80	0.04	0.04	0.04	....	....	0.80	1.10	0.18	....	....	....
SM-15 Class A	Carbon	0.90	1.10	....	0.50	0.05	0.05	0.05	....	....	....	....	....	....	....	....
Class B	Carbon	0.95	1.15	....	0.50	0.05	0.05	0.05	....	....	....	....	....	....	....	....
SM-16	Chrome-molybdenum	0.40	0.50	0.40	0.60	0.045	0.04	0.04	....	0.25	0.80	1.10	....	....	0.30	0.50
SM-17 Class A	Carbon	0.70	0.90	0.25	0.50	0.05	0.04	0.04	....	0.25	May be included according to supplier's judgment in which case only phosphorus and sulphur requirements need be met.					
Class B	Carbon	0.90	1.10	0.25	0.50	0.05	0.04	0.04	....	0.25						
Class C	Carbon	0.55	0.65	1.00	1.25	0.05	0.04	0.04	0.12	0.20						
Class D	Carbon	0.78	0.85	0.40	0.55	0.05	0.04	0.04	0.12	0.20						

NOTE: The materials specified by SM-1, -2, -3, -5A, -7A, -7B, -8A, -8B, and -15A may be either rolled or drawn for use in either elliptic or helical springs. Materials specified by SM-4B, -5B, -15B, -17B, -17C, and -17D may be drawn only for use in helical springs. Materials specified by SM-6A, -6B, -9, -10, -11, -12, -13, -14, -16, -17A and -17B may be rolled only for use in elliptic springs. The "A" and "B" grades or classes in all except SM-17 denote, in addition, the relative severity of stress or service to which the material in question should be subjected.

Permissible Variations in Gage Dimensions

The Pennsylvania Railroad specification (S-1 in preceding list) makes no particular effort to control the dimensions of unfabricated rolled or drawn stock, except to state that "the inspector shall check the dimensions of not less than 10 per cent of helical springs and not less than 25 per cent of elliptic springs" and that "springs shall conform to standard drawings...showing...dimensions."

The American Society for Testing Materials make the following statement in regard to permissible variations in dimensions: "The permissible variations in the width and thickness of the bar shall be agreed upon by the manufacturer and the purchaser."

On the other hand, the Society of Automotive Engineers, the U. S. Navy, and the American Railway Association each state to a more or less degree the permissible variations in dimensions.

In the automotive industry flat bar stock is double concave as shown in Fig. 1. The Society of Automotive Engineers recommends that the radius of the mill roll which makes the round edges be equal to two-thirds of the plate thickness. The difference in edge thickness, i.e., $\pm t_1 \mp t_2$, is specified as follows:

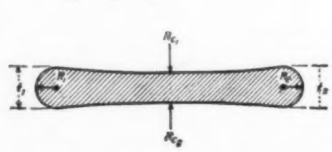

Fig. 1 Cross-Section of Double-Concave Flat Bar Stock

Width, in. Over	Width, in. To, inclusive	Difference, in.
0	2	0.002
2	3	0.003
3	5	0.004

Leaf-spring steel bars shall not have more than 1 in. curvature in 20 ft. or $1^1/_4$ in. in 25 ft. or $1^1/_2$ in. in 30 ft. The concavity, or difference between the thicknesses at the edges and at the center of the bar, shall be specified as follows:

Width, in.	Normal concavity, in.	Max. concavity, in.	Min. concavity, in.
1½	0.007	0.009	0.004
1¾	0.008	0.010	0.005
2	0.010	0.012	0.006
2¼	0.011	0.013	0.007
2½	0.013	0.015	0.009
3	0.016	0.018	0.012
3½	0.018	0.020	0.013
4	0.021	0.023	0.016
5	0.029	0.031	0.023

Round or Square Drawn Stock
(American Railway Assn.)

Size	Diameter or thickness, in. Over	Diameter or thickness, in. Under
Up to 5/16 in., inclusive	0.005	0.005
Over 5/16 to 7/16 in., inclusive	0.007	0.005
Over 7/16 to 5/8 in., inclusive	0.009	0.005
Over 5/8 to 7/8 in., inclusive	0.010	0.006
Over 7/8 to 1 in., inclusive	0.011	0.007
Over 1 to 1⅛ in., inclusive	0.012	0.008
Over 1⅛ to 1¼ in., inclusive	0.013	0.009
Over 1¼ to 1⅜ in., inclusive	0.014	0.010
Over 1⅜ to 1½ in., inclusive	0.016	0.011
Over ½ to 2 in., inclusive	0.019	0.012

The U. S. Navy in the case of round bars allows a variation of 0.02 in., plus or minus, in diameter.

Physical Tests of Springs

In nearly all cases the physical properties or necessary heat treatments are not specified, but instead certain physical tests on the finished springs are required. From the practical standpoint this is the best method but it is not a scientific one, since such tests do not give any indication as to the probable life of the spring, and in the case of less than 100 per cent inspection, no control is had over springs with maximum accumulative variations.

For helical springs the following physical tests are made:

1 Solid height
2 Free height
3 Loaded height
4 Permanent set

TABLE 2 PERMISSIBLE VARIATIONS IN GAGE DIMENSIONS

Flat Rolled Stock

Specification	Width, in. Over	Width, in. Up to and including	Tolerances in width, in. Plus	Tolerances in width, in. Minus	Tolerances in thickness, in. Up to 3/8 in. inclusive Plus	Up to 3/8 in. inclusive Minus	Over 3/8 including 5/8 in. Plus	Over 3/8 including 5/8 in. Minus	Over 5/8 including 1 in. Plus	Over 5/8 including 1 in. Minus	Over 1 including 2 in. Plus	Over 1 including 2 in. Minus	Over 2 in. Plus	Over 2 in. Minus
SM-17 U. S. Navy	..	1	1/64	1/64	0.007	0.007	0.010	0.010	0.012	0.012	....	....	....	....
	1	2	1/128	1/128	0.010	0.010	0.012	0.012	0.015	0.015	0.020	0.020	....	....
	2	4	1/32	1/32	0.010	0.010	0.012	0.012	0.015	0.015	0.020	0.020	1/32	1/32
	4	6	1/16	1/16	0.010	0.010	0.012	0.012	0.015	0.015	0.025	0.025	1/32	1/32
	6	8	3/64	3/64	0.012	0.012	0.015	0.015	0.020	0.020	0.025	0.025	1/32	1/32

Specification	From	To Inclusive	Plus	Minus	Up to 3/8 in. inclusive Plus	Up to 3/8 in. inclusive Minus	Over 3/8 to 3/4 in. inclusive Plus	Over 3/8 to 3/4 in. inclusive Minus
SM-15 American Railway Association	1	2	0.015	0.015	0.015	0.005	0.015	0.010
	2	4	0.047	0.015	0.015	0.005	0.015	0.010
	4	5	0.047	0.032	0.015	0.005	0.015	0.010
	5	6	0.062	0.032	0.015	0.005	0.015	0.010
Society of Automotive Engineers	0	2¼	1/32	0	All thicknesses plus or minus 0.005 in.			
	2¼	3	3/64	0	All thicknesses plus or minus 0.006 in.			
	3	5	1/16	0	All thicknesses plus or minus 0.007 in.			

The solid height is the perpendicular distance between the plates of the testing machine when the spring is compressed solid with a test load of at least one and one-quarter times that necessary to bring all coils in contact.

The free height is the height of the spring when the test load specified for determining the solid height has been released, and is determined by placing a straight-edge across the top of the spring and measuring the perpendicular distance from the plate on which the spring stands to the straight-edge at the approximate center of the spring.

The loaded height is the distance between the plates of the testing machine when the specified working load is applied.

The permanent set is the difference, if any, between the free height and the height after the spring has been compressed solid three times in rapid succession with the test load specified for determining the solid height, measured at the same point and in the same manner.

The limits allowed for these physical tests by the various specifications listed are given in Table 3.

TABLE 3 ALLOWABLE LIMITS FOR PHYSICAL TESTS, HELICAL SPRINGS

Specification	Following heights shall not vary from those specified: Solid height Plus	Solid height Minus	Free height Plus	Free height Minus	Loaded height Plus	Loaded height Minus	Permanent set shall not exceed
S-1 (Penn. R. R.)	1/16 in.	....	1/16 in.	....	....	0	1/32 in.
S-2 (A.S.T.M.)	1/8 in.	1/8 in.	1/8 in.	1/8 in.	1/8 in.	1/16 in.	1/32 in.
S-5 (A.R.A.)	1/8 in.	1/8 in.	1/8 in.	1/8 in.	1/8 in.	1/16 in.	1/32 in.

For elliptic springs the following tests and permissible results are specified.

Railway Springs

a The free height is the height from the center line of spring-eyes to face of leaf at center of spring seat after a test load of $1^1/_2$ times the specified normal load (working load) has been applied and fully released.

b The loaded height and loaded length are respectively the height and length when the test load in *a* has been applied and is slowly released to the specified normal load. The loaded height shall not be less, but may be $^3/_8$ in. more, than that specified. The loaded length shall not vary more than $^1/_4$ in. from that specified.

c The permanent set is the difference, if any, between the free height and the height after the test load has been applied again

and fully released. If the permanent set is less than $^1/_{32}$ in., a second test for permanent set after two additional applications of the test load shall not show any further permanent set.

Automotive Springs

a The maximum test load shall be twice the specified normal load (working load), provided the corresponding deflection is possible from the standpoint of interference under the car. Otherwise the load corresponding to the maximum possible deflection shall be the maximum test load.

b The loaded height is the height when the specified normal load is applied after the maximum test load of *a* has been applied and fully released three times. The loaded height in the case of pleasure cars, unless otherwise specified, shall not be less, but may be $^1/_4$ in. and $^3/_8$ in. more, than that specified for front and rear springs, respectively.

c The permanent set is the difference, if any, between two successive measurements of the height under a load equal to 75 per cent of the specified normal load. This load shall be applied for the first time after the maximum test load has been applied and fully released three times, and for the second time after the maximum test load has been applied again and fully released. The permanent set shall not exceed $^1/_{16}$ in., but if to the contrary, the maximum test load shall be applied again and fully released two additional times and a load equal to 75 per cent of the specified normal load applied a third time. No additional permanent set shall be allowed after this second test.

d The flexibility, in pounds per inch of deflection, shall be determined by measuring the height under 75 per cent of the specified normal load and the height under 125 per cent of that load and dividing the difference in loads by the difference in heights. The flexibility shall not vary from that specified more than 5 per cent.

The above physical tests are effective only to the extent that they assure the attainment of certain operative requirements of load and corresponding deflections within reasonable limits. In the case of certain specifications they further assure that the springs will withstand a maximum static load corresponding to a fiber stress of 90,000 lb. per sq. in. for helical springs and 127,500 lb. per sq. in. for elliptic springs, irrespective of type of steel (unless otherwise agreed upon). The formulas recommended by the A.S.T.M. for calculating test loads based upon these stress figures are as follows:

Helical springs

$$P = \frac{3.1416Sd^3}{8D_m}$$

Elliptic springs

$$P = \frac{2Snbh^2}{3L}$$

where P = load, S = fiber stress, d = diameter of material, h = thickness of material, b = width of material, D_m = mean diameter of helical spring, L = length of elliptic spring, and n = number of leaves in a semi-elliptic and one-half the number of leaves in a full-elliptic spring. Units are pounds and inches.

These physical tests do not take into account the probable life of the spring or, in the case of less than 100 per cent inspection, the effect of cumulative variations on operation and life. More adequate control may be accomplished by the specification of heat treatment and expansion of knowledge on the design of springs in general, and on spring fatigue. The Society of Automotive Engineers and the American Society for Steel Treating furnish heat-treatment specifications for spring steels; the compositions of the A.S.S.T. steels and their heat treatments are given in Tables 4 and 5.

TABLE 4 COMPOSITION OF A.S.S.T. SPRING STEELS

Designation for this paper	Steel	Carbon	Manganese	Phosphorus	Sulphur	Silicon	Chromium	Vanadium	Molybd.
SM-18	Carbon	0.90	0.30	0.040	0.050	0.10	....	....	....
		1.05	0.50	....	....	....	....	....	....
SM-19	Chrome	0.45	0.80	0.040	0.050	0.10	1.00	....	....
		0.55	1.00	....	....	0.20	1.20	....	....
SM-20	Chrome-	0.45	0.70	0.040	0.050	0.10	1.00	0.15	....
	Vanadium....	0.55	0.90	....	....	0.20	1.20	0.25	....
SM-21	Chrome-	0.45	0.70	0.040	0.050	0.10	0.70	....	0.20
	Molybdenum	0.55	0.90	....	....	0.20	0.90	....	0.30
SM-22	Chrome-Silico-	0.45	0.70	0.040	0.050	0.40	0.70	....	....
	Manganese...	0.55	0.90	....	....	0.60	0.90	....	....
SM-23	Silico-	0.55	0.70	0.045	0.050	1.80	....	....	....
	Manganese...	0.65	0.90	....	....	2.10	....	....	....

TABLE 5 HEAT TREATMENTS FOR A.S.S.T. SPRING STEELS

Designation for this paper	Steel	Normalizing temperature, deg. fahr.	Hardening temperature in deg. fahr. quench in oil. Time of heating = diameter × 60	Approx. tempering temperature, deg. fahr., to give Brinell in adjacent column	Brinell Hardness number
SM-18	Carbon	1575–1625	1525	600–950	352–415
SM-19	Chrome	1600–1650	1525	650–950	363–444
SM-20	Chrome-Vanadium	1600–1675	1550–1600	675–975	363–444
SM-21	Chrome-Molybdenum	1600–1675	1550–1600	675–975	363–444
SM-22	Chrome-Silico-Manganese...	1600–1650	1600–1650	675–975	363–444
SM-23	Silico-Manganese	1600–1650	1600–1650	650–950	363–444

WORKMANSHIP

The specifications considered cover this item by a statement ranging from a simple reference to "injurious defects" to a more lengthy paragraph on inspection of general dimensions and workmanship. Some of the points covered are as follows:

Helical Springs. The springs shall be of uniform pitch with ends tapered to give a reasonably square, firm bearing. The points of bars shall not protrude beyond the outside diameter of the springs.

The outside dimensions of the springs, excepting the height, shall not vary more than $^1/_{16}$ in. from those specified. In the A.R.A. and Penn. R.R. specifications this requirement is covered under "permissible variations." In the latter section of the A.R.A. specification it is also stated that when under the specified normal load, at the loaded height, the spring shall be of uniform pitch within 15 per cent of the bar diameter throughout its length, excluding the tapered section.

Elliptic Springs. Dimensions which affect contour only and do not affect the interchange or service of the springs need only be approximated.

The springs shall have the leaves properly graduated in length, properly bent, and fitted to reasonably true circular arcs.

The bands of the springs shall not vary from the specified dimensions more than $^1/_{16}$ in. in width and $^1/_{32}$ in. in thickness of straps, nor more than $^1/_8$ in. in width across the spring.

SPECIFICATIONS COVERING SMALLER-SIZE SPRINGS

The foregoing discussion was in connection with the specifications covering large helical springs of the compression type and elliptic springs used in the U. S. Navy and the railway and automotive industries. To develop a form of specification for smaller mechanical springs, the more generalized features of the large-spring specifications may be followed, although certain important deviations must be made to satisfy vastly different conditions.

The layout of a specification for small springs would, in a general way, follow the topical outline given earlier in the paper. The title of a specification exclusively for manufacturing would be very brief and would have a "piece-part" code number, as, for example,

Helical Spring (Extension) P-145012

The scope or use to which the spring is to be submitted would consist of a brief reference to the assembly or partial-assembly code number of the mechanism in which the spring is to operate, as, for example,

MT-1 Typewriter A-4567

In all other types of specifications the title would not include any code numbers, but would give some indication of the general use to which the spring is to be put.

The scope should be somewhat more explanatory than in the case of exclusive manufacturing specifications or in the case of the standard specifications for large springs. The approximate limits of the proposed service should be stated briefly, such as the probable number of operations and accidental overloads, the relative certainty of these limits, severity of corrosion, elevated temperatures, and the relative importance of the spring to the operation of the mechanism in which it is assembled. The number of operations bears a very important relation to the fatigue breakdown of the spring, and enough fatigue data are at hand to show that a spring which is to deflect one million times should be designed differently from one which is to deflect 12 million times or 50 thousand times.

SPRING MATERIALS FOR SMALL SPRINGS

In general, the raw material for small springs is referred to as "wire." The cross-section, which may be round, rectangular,

or square, is obtained by the repeated drawing of a bar through a round die. Rolling of a round wire then produces a flat wire. Flat springs may be punched out of a rolled sheet, but this is not considered good practice unless the width contour is not straight with parallel edges. Drawing the wire cold, annealing within the intermediate draws, and leaving the last draw unannealed introduces strain-hardening or cold-work into the material, thereby giving it the desired spring temper. Increasing the carbon content in steel up to 0.85 per cent, the tin content in phosphor bronze up to 10 per cent, or other similar manipulation of the chemical analysis further increases the spring temper. Strain-hardening of this kind must not be carried too far, however, or the material will be damaged internally, which fact makes the cold-drawing of high-carbon steel (music wire) very difficult, since the number of intermediate annealings are greater than is required for lower-carbon steel. Aside from internal damage, the introduction of considerable strain, while increasing the proportional limit, decreases the ductility to an unsafe amount. Thus so-called "soft" springs are best for severe vibration service, particularly with high fiber stress. Steel wire made in the above manner and having the following typical analysis is known as music wire.

Carbon	0.85 per cent
Manganese	0.45 to 0.50 per cent
Sulphur	0.02 per cent
Phosphorus	0.025 per cent
Silicon	0.15 per cent

Such material in 0.024-in. round wire will give tensile strengths as high as 400,000 lb. per sq. in. and a tensile proportional limit of about 200,000 lb. per sq. in. In the calculation of helical springs it is customary to use a torsional fiber stress of 100,000 lb. per sq. in. for ordinary service, and as low as 60,000 lb. per sq. in. for very severe service. It is possible, however, by the manufacturing process of "surging" a helical spring of small spring index, to develop a torsional fiber stress as high as 200,000 lb. per sq. in.

Fortunately the heat-treating properties of steel allow of better methods whereby spring temper may be imparted to this metal. One method is to hot-draw a 0.65 per cent carbon steel, harden it in oil, and temper to give the desired proportional limit. Although this wire, which commercially is known as oil-tempered wire, has a much lower tensile strength than music wire—of the order of 200,000 lb. per sq. in.—its tensile proportional limit is relatively higher, being about 75 per cent of the tensile strength. Oil-tempered wire is cheaper than music wire and is used in great quantities for springs.

The other method of imparting spring temper to wire is to wind or make the spring first from the wire in the annealed state and then to harden and temper the formed spring. Alloy-steel-wire springs are made in this manner.

A summary of the common materials used in the manufacture of small mechanical springs is as follows:

1 Music wire (steel), cold-drawn to give desired temper, average per cent of carbon = 0.85
2 Premier wire, cold-drawn, 0.60 per cent carbon steel
3 Oil-tempered wire, hot-drawn, 0.65 per cent carbon steel. (By continuous process wire is hardened and tempered)
4 Annealed steel wire heat-treated after forming of spring
5 Alloy steels, hot- or cold-drawn, annealed and then formed into springs, which is then hardened and tempered. Same analysis as for large springs
   Chrome-vanadium steel
   Silico-manganese steel
   Chrome-molybdenum steel
6 Phosphor bronze, rolled or drawn to temper; 4 to 8 per cent tin
7 Nickel silver, rolled or drawn to temper; 55 per cent copper, 18 per cent nickel, 26 per cent zinc
8 Monel metal, rolled or drawn to temper.

The physical properties of the above materials are likely to vary widely with the different manufacturers. It should be possible, however, to secure limiting values in the important properties of the standard materials. These figures should not be included in the specification unless they can be easily checked by swaging, twisting, bending, or hardness tests. For calculations the commercial limits in the proportional limit, modulus of elasticity, ultimate strength, and, if possible, the endurance limit should be known.

Gage and Gage Variations in Spring Materials

There are many systems of wire gages in existence, but for ordinary steel wire used in springs, the Washburn & Moen system is most commonly used. Steel music wire has a special gage of its own, while the Birmingham wire gage is used for specifying the thickness of flat steel wire. Phosphor bronze and nickel silver in both sheet and wire are specified by the Brown & Sharpe system. Considerable confusion is caused by these many systems, and this matter is now before the A.E.S.C. for clarification. If the use of several wire standards is allowed to continue, it will be more convenient and less confusing to state wire sizes in decimals of an inch only.

The usual variations in thickness specified by any of the usual gages, whether it be in round wire, flat wire, or sheet form, in commercial practice is 2 to 3 per cent. The width of flat wire may vary by a similar amount, but in the case of sheet stock it may be as follows:

Width	Variation
3/8 in. and under	0.007 in
Over 3/8 in. to 3/4 in., inclusive	0.008 in.
Over 3/4 to 1 in., inclusive	0.010 in.
Over 1 in.	1/64 in.

Dimensional Variations Due to Manufacture

The method of manufacture if commercial must unavoidably introduce certain variations in the finished springs. Indirect-sale manufacturers in most cases make all their springs, irrespective of quantity, by the methods which direct-sale manufacturers use only for small lots of springs, say, one thousand or less. The latter have developed automatic machinery and modern tools for quantity production, which has resulted in better control over variations. Only a few of the large indirect-sale manufacturers have adopted these methods, and it would pay many other large concerns to segregate all their spring manufacturing into an efficient department.

Small Quantities. Helical springs of both the extension and compression type are wound cold over an arbor set in a lathe. Since considerable tension has to be applied to the wire, stretching will reduce its diameter, and if the tension is insufficient the spring diameter will increase. Both of these variations tend to decrease the load-deflection rate of the finished spring. The pitch of the spring, which is controlled by the lead screw of the lathe, may also vary slightly. In a compression spring this variation would cause a stiffening of the spring as it was being deflected, resulting in the type of load-deflection curve shown in Fig. 2, while in an extension spring initial tension would be introduced and the load-deflection curve shown in Fig. 3 would be obtained.

Large Quantities. In manufacturing large quantities of helical springs, rollers actuated automatically by cams upset the wire on the outside of the finished coil, constituting a method which might be called "outside winding" as compared with "inside winding" by the arbor method. The entrapped stresses in these two methods are quite different in type and magnitude, which probably accounts for the different variations in springs made by them.

In either outside- or inside-wound springs torsional overstrain is introduced by the commercial process known as surging for the purpose of raising the torsional proportional limit. Helical springs, particularly those wound with low bending stresses (large indices), are heated under a low temperature to eliminate the dominating effect of entrapped stresses.

Springs wound from annealed wire and then hardened and tempered are subject to considerable variations in dimensions when not carefully controlled.

From the foregoing discussion it is obvious that the physical properties of the material play a considerable part in the variations introduced during the manufacture of the spring. Each type of spring also presents its own problems as regards commercial manufacturing variations. In general, the total actual range in commercial variation of the load-deflection rate is about 8 per cent, but the possible maximum range due to cumulative variations is somewhat greater.

To control the purchase of springs subject to the above maze of manufacturing variations is more difficult than in the case of large springs consisting of only two general types (helical and elliptic) and a smaller variety of materials (all steels). The measurement of the principal dimensions and permanent set of small springs is not so practicable, and in places where it is done on a 10 per cent basis a special laboratory with skilled personnel is provided. The specification devised must satisfy the two following essential yet antagonistic requirements: (1) they must be adequate, and (2) they must be commercial. To meet the first requirement the maximum possible cumulative variations should be definitely related to the operating characteristics of the spring. Based upon this

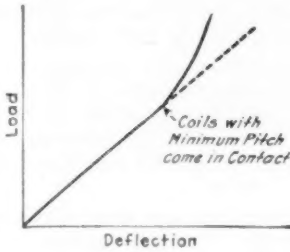

Fig. 2

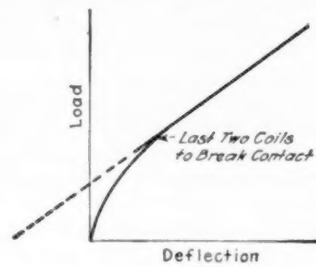

Fig. 3

FIG. 2 COMPRESSION SPRING WITH VARIABLE PITCH

FIG. 3 EXTENSION SPRING WITH VARIABLE PITCH (INITIAL TENSION)

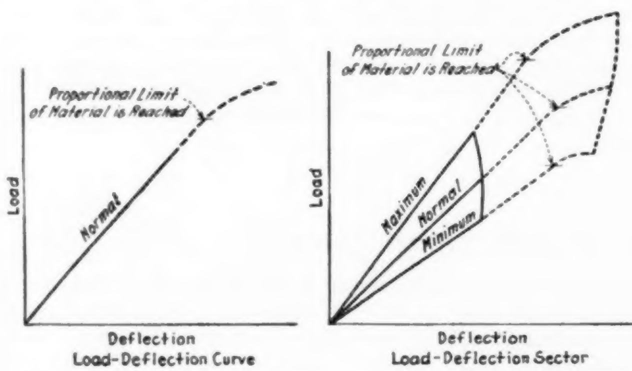

FIG. 4 LOAD-DEFLECTION CURVE AND LOAD-DEFLECTION SECTOR

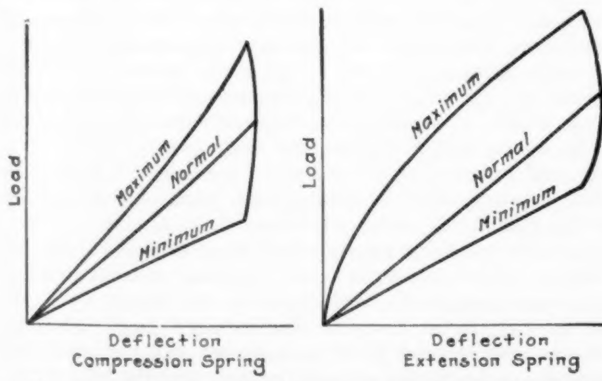

FIG. 5 LOAD-DEFLECTION SECTORS FOR CASES ILLUSTRATED IN FIGS. 2 AND 3

principle the author wishes to introduce in this paper his idea of a "load-deflection sector" to be used in place of the load-deflection curve, and to employ this idea in framing a sample specification. Fig. 4 illustrates the meaning of the load-deflection sector. Fig. 5 shows a sector including the type of variation shown in Figs. 2 and 3.

LOAD-DEFLECTION SECTORS SHOWING EFFECT OF VARIATIONS DUE TO NON-UNIFORM PITCH

By encouraging engineers to think in terms of load-deflection sectors instead of curves, we shall be training them to control the overall condition including manufacturing methods and commercial limitations, instead of narrowing themselves down to the mere technical requirements. With this general principle in mind the following specification has been drawn up for a helical spring in which commercial considerations of cost required very liberal variations.

SPECIFICATION

JOHN DOE MFG. COMPANY, CHICAGO, ILL.

STEEL HELICAL SPRING—PART 11-F-14

Scope—This specification covers a steel helical compression spring to be operated under a continual load that is to be oscillated about one million times in normal air during a period of about 5 years.

Specifications

1 Operation:
- *a* Load-deflection sector............ $70 {+20 \atop -15}$ lb. per in.
- *b* Solid load........................ As per test $\left(235 {+90 \atop -60}\right.$ lb.)
- *c* Test load........................ 175 lb.
- *d* Working load.................... 130 lb.
- *e* At working load, permanent set shall not exceed................ $^1/_{32}$ in.

2 Material:
Spring steel, oil-tempered wire, acid or basic open-hearth, carbon, 0.60 to 0.75 per cent

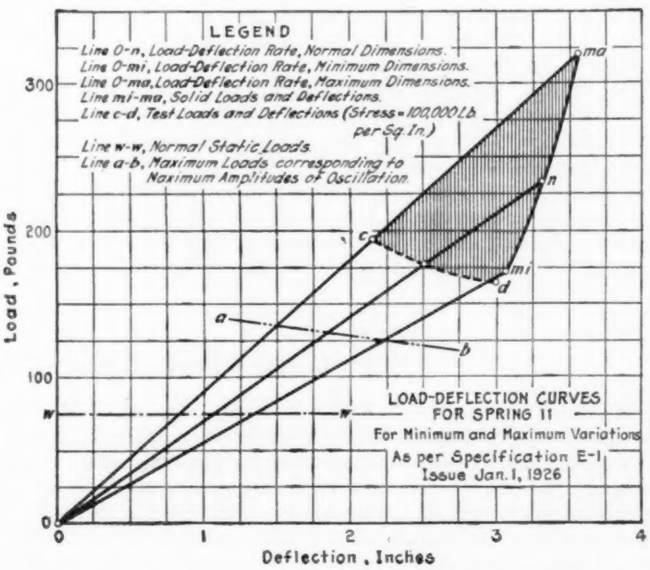

FIG. 6 LOAD-DEFLECTION CURVES TO ACCOMPANY SAMPLE SPRING SPECIFICATION

3 Dimensions:
- *a* Gage......................... $\frac{5}{32} {+0.003 \atop -0.002}$ in.
- *b* Outside diameter................. $1 \pm {}^1/_{32}$ in.
- *c* Solid height[2].................... $3^7/_{16} \pm {}^1/_8$ in.
- *d* Loaded height[3].................. $5^5/_{16} + {}^1/_8 - {}^1/_{16}$ in.
- *e* Free height...................... $6^3/_4 \pm {}^1/_8$ in.
- *f* Pitch........................... $^5/_{16} \pm {}^1/_{64}$ in.

4 Number of active turns............... $21 + 1 - 1^1/_4$
Number of inactive turns (ends)....... 1

5 Style of ends........................ Squared only

6 Heat treatment of springs............ None

7 Finish.............................. Black enamel.

Inspection Tests

8 Chemical analysis: Test samples shall be taken at random from the shipment and analyzed for carbon. The steel shall be free from slag inclusions and otherwise of sound crystalline structure.

9 Physical tests: 10 per cent of the shipment chosen at random shall be submitted to the following tests:
- *a* Springs shall be compressed solid 3 times with $1^1/_4$ times the actual test load (1c) before test load is applied again and released to free height
- *b* Difference, if any, from free height (3e) as received from manufacturer is permanent set
- *c* Permanent set shall not exceed the amount specified (1e)
- *d* Load-deflection rate must be within specified limits (1e).

10 Guarantee: The manufacturer shall guarantee operating characteristics that fall within the load-deflection sector below the line *a-b*.

[2] After being compressed solid three times with at least $1^1/_4$ times the test load (1c).

[3] Height corresponding to working load (1d).

He shall further guarantee that permanent set for loads and deflections below the line *a-b* will not be greater than $^1/_{32}$ of an inch, and that failure by breakage will not occur within the sector below the line *c-d* for the conditions pointed out in this specification. If the manufacturers by testing a normal spring can show that the actual load-deflection curve does not coincide with the normal line *o-n* he shall have the right to shift the entire sector until the normal line coincides with the actual test line. He shall then base his physical-test requirements on the sector in the revised position if agreeable to both manufacturer and purchaser (see Fig. 6).

Rejection

11 Shipments which do not comply with the above specifications and inspection tests will not be accepted.

12 No exception to rejection will be considered after 10 days' notice by the purchaser.

13 Unless otherwise agreed upon, all expenses involved in the rejection of a shipment will be charged to the manufacturer or supplier.

Discussion

FOLLOWING the presentation of his paper, the author, in reply to a question asked by P. A. Porter,[4] said he did not believe that bending a helical spring until its ends were brought together would be a wise test to adopt. It might be called a safe test, however, because it would be effective in cases where the springs were being worked up to their maximum capacity by loads which tended to buckle the springs.

As to the advantage of making springs of specially formed wire, concerning which B. P. Graves[5] inquired, the author, recounting his experience in an extreme case of this kind, said that a special wire of rectangular cross-section had been substituted for round wire in the motor spring used in telephone dials, which devices were coming into service in greater numbers every day. The designer of the dial had apparently thought that the spring was an insignificant matter and had left only a limited amount of space for it. The spring had then been designed, tested, and improved upon in different ways to meet a very severe service. The best kind of spring material, steel music wire, had been used, hence the best possible spring using round-section wire had been obtained. However, a considerable number of the dial springs had broken in service, which had been a serious matter. In reconsidering the design it had been found that a 24 per cent improvement was possible provided a specially formed steel wire having a rectangular section and equal physical properties were used. The author had gone to a wire manufacturer and found that he was not anxious to supply such a wire unless a certain accomplishment could be guaranteed with it. Thus the matter resolved down to a commercial problem in which specially formed wire might be satisfactorily specified in cases where the spring was important enough to bear the expense.

In the case of round wire, practice was fairly well established. The round-wire spring could be easily wound on a mandrel, but in the case of a spring wire having a rectangular section the wire had a tendency to twist. Specifying special springs of this kind involved certain manufacturing difficulties, but such springs could be and were being made. The essential thing was that such a spring cost more.

W. T. Donkin[6] emphasized the necessity of coöperation between the manufacturer and the user of springs. The manufacturer, he said, could not intelligently design a spring unless he knew how and where it was going to be used. The spring manufacturers had been doing considerable research work in regard to defects in steel. The first defect they had looked for was dirty steel, and in their microscopic examinations they had found that nearly every spring that had broken had shown visible surface defects. They had taken up the matter with the wire manufacturers and were now getting wire entirely free from surface defects, and had cut their breakage in this manner from about 90 to 10 per cent of its former value.

Fatigue—Industrial Posture—Waste Elimination

FATIGUE was dealt with briefly in a paper by Dr. E. R. Hayhurst, of the College of Medicine of the Ohio State University, at a dinner meeting of the committee for the elimination of unnecessary fatigue at the thirteenth national convention of the Society of Industrial Engineers, held in Philadelphia, June 16–18. Because of Dr. Hayhurst's absence, the paper was read by Prof. G. H. Shepard, Purdue University, chairman of the society's fatigue committee.

In answer to the question, "When do we know that the day's work is fatiguing?" it was said that there were so many conditions creating the same symptoms of tiredness as fatigue that this question was difficult to answer in the individual case. In a group of workers it was easier. The following criteria were given: General complaints of tired feeling at close of work periods; many health complaints, requests for time off; too many quittings; "fagged" appearance of numbers of workers; defective output, not necessarily decreased output, except when measured by the week or month; lessened desire to work, disloyalty; more precisely, the evidence discovered on inspection that many of the intrinsic and extrinsic causes of fatigue were present.

At this meeting also some of the first principles of industrial posture and seating were outlined by Miss Nellie Swartz, director of the bureau of women in industry, of the New York State Department of Labor.

In the work of Miss Swartz's bureau it has been found that the possibility of good posture is not assured by having a good chair, but that relating of the chair and worker to the work bench and material is necessary. Two recommendations were made as to the result of investigations of the bureau. One is that posture should be varied. The ideal condition is that the worker should be able to stand at will, change in posture providing rest and saving a great deal of energy. Another principle suggested was the placing of the worker in proper relation to the work place. The worker should not have to sit on the edge of a chair to reach a foot pedal, or be required to sit improperly in a chair in order to reach up to get materials.

The most satisfactory industrial chair was said to be one having wood in its construction. The question of backs to the chairs is important, and it was said that a small bar that fits into the small of the worker's back gives the necessary support and does not interfere with the arms of the worker. The connection of the seating area and the back of the chair should come in and give support to the back. The seating area does not have to be large if the worker can sit far back. Edges of the chair should not be sharp, nor long, and interfere with freedom of the worker's legs. The chair should be adjustable as to height and adjustable so that the back of the chair fits the small of the back of the workers.

The increased necessity for the elimination of waste in all departments of industry, because of the shortage of labor and impending intense struggle for world markets was stressed by L. W. Wallace, secretary of the American Engineering Council, Washington. It was only through good management and the maximum utilization of our productive energies, he said, that the labor shortage would be offset.

Actual cases of waste due to lack of coördination between the various parts of a business were presented by several speakers at the "management" session, held on the opening day of the convention. An outstanding contribution at this session was a paper on Job Manufacturing and Executive Coördination, by W. W. Crawford, president of the Edward Valve & Mfg. Co., East Chicago, Ind. Reducing waste by establishing coördination between the sales and credit departments of a business was dealt with interestingly by T. D. Nevins, of Miller, Franklin, Basset & Co., New York, and the complexity of the distribution problem was discussed at length by Alvin E. Dodd, manager of the domestic distribution department of the Chamber of Commerce of the United States. (Condensed from *The Iron Age*, June 24, 1926, pp. 1781–84.)

[4] Engineering Department, Morgan Construction Co., Worcester, Mass. Mem. A.S.M.E.

[5] Milling Mch. Engr., Designer, Brown & Sharpe Manufacturing Co., Providence, R. I. Mem. A.S.M.E.

[6] Engineer, Cleveland Wire Spring Co., Cleveland, O. Jun. A.S.M.E.

Diphenyl Oxide Bi-Fluid Power Plants

By H. H. Dow,[1] Midland, Mich.

The object of the author in presenting this paper is to give particulars regarding a system that, it is believed, will convert a little larger percentage of the heat in coal into mechanical power than has been done by any system heretofore. There is indeed a system which will convert the heat in oil through a Diesel engine and which, using the waste heat from the Diesel engine in steam boilers, will show a higher thermal efficiency than the one about to be described, which is based on the use of coal (which is very much cheaper per B.t.u. than oil), so that the two are not comparable from the dollars-and-cents standpoint.

Essential Requirements of Efficient Power Plants

It is well known that, according to thermodynamic principles, the maximum efficiency of conversion of heat into power that can be obtained between given high and low temperature limits is that of the Carnot cycle. The efficiency according to this cycle is equal to

$$\frac{T_1 - T_2}{T_1}$$

where the temperatures are measured on the absolute scale and where all the heat is put into the working fluid at the highest temperature T_1 and removed from the fluid at the lowest temperature T_2. For example, half of the heat energy in a fuel could be converted into power in a perfect engine if a fluid having no specific heat were boiled at 600 deg. fahr. and condensed at 70 deg. fahr. The Carnot-cycle efficiency would be

$$\frac{(600 + 460) - (70 + 460)}{600 + 460}$$

or 50 per cent.

Seventy degrees is taken as a starting point here, for it is about the lowest temperature to which a fluid can be expanded in a power plant without the use of an excessive amount of condensing water.

We are also limited at the upper end of the temperature scale, and, until the advent of the new chromium steel, it was impossible for a superheater pipe to withstand more than 725 deg. fahr. without deterioration. We know that at 750 deg. fahr. there is no creep of the metal. We know that at 900 deg. there is a creep. Whether there is a creep at 800 deg. or not we are not quite sure, but we do know that when we attempt to operate an ordinary superheater at 750 deg., it will occasionally go enough above 800 deg. so that there will be a creep in the pipe, which means abnormal depreciation.

In Table 1, even where we get the high efficiencies of 80, 93, and 95 per cent in certain steps, the Carnot-cycle efficiency is only 45 per cent. All these other steps are so near 100 per cent that there is little opportunity of improving them. For this reason we may conclude that practically the only way of getting more horsepower from a heat unit is to go to a higher temperature at the upper end of the heat cycle, that is, increase the Carnot-cycle efficiency. This requires that all of the heat be put into the fluid at the upper temperature limit of the cycle, which has not always been fully realized by engineers in general. In a boiler plant provided with an economizer they will consider the B.t.u that go into the economizer in the same sense as if they had gone into the original boiler; this despite the fact that the Carnot-cycle efficiency of the heat that goes into the economizer is not over 20 per cent, whereas the Carnot-cycle efficiency of the heat that goes into the boiler at 600 deg. fahr. is 50 per cent.

Sources of Loss Due to Not Putting in Heat at Top of Cycle

We are also limited in many other ways. For example, the modern steam plant, with its steam superheated to 750 deg. fahr., does not absorb the bulk of the heat from the coal at that temperature. If the steam pressure were in the neighborhood of 700 lb. per sq. in., the water would boil at about 500 deg. fahr., and most of the heat from the coal would be utilized in boiling the water at this temperature. We should then have a Carnot-cycle efficiency corresponding to 500 deg. as the upper limit and 70 deg. as the lower limit, which is approximately 45 per cent. This would be increased only a moderate amount by superheating, because the amount of heat absorbed as superheat is relatively small.

This 45 per cent is decreased very materially in an ordinary plant because part of the heat in the coal has to raise the temperature of the condensate water from 70 deg. to the boiling point at 500 deg. There is a way, however, to circumvent this loss, namely, by the so-called bleeder system, whereby steam that has already been utilized to a certain extent in a steam turbine and has lost some of its heat, is extracted therefrom to heat the boiler feedwater. Here only heat that has been put in at the top of the heat cycle is utilized to raise the temperature of the condensate nearly to the temperature at which the water is boiling. This method of bleeding, if carried out in an infinite number of steps, would make the Rankine cycle and the Carnot cycle exactly the same.

In practice, the method can be carried out only imperfectly; that is, the B.t.u. that are absorbed by the boiler have only about 90 per cent of the value they would have if they were absorbed at 500 deg. in the examples cited. This 90 per cent is the ratio of the Rankine efficiency to the efficiency theoretically possible under the working temperature if all the heat were put in at the top of the heat cycle, namely, at 500 deg.

The other loss in power plants, namely, that incurred in heating the air from the outside temperature to that of the stack, can be largely eliminated by a heat interchanger, whereby the stack temperature may be reduced to within 100 deg. of that of the surrounding air, and the heat of the air fed into the furnace can be increased by the amount of heat that the stack gases lose.

Proposed Remedies

Air Preheating. This method of increasing the efficiency of power plants, although well known and applied in the steel industry for at least two generations, has not been utilized to any extent in power-plant practice until very recently. In no case, so far as the author is aware, has it been used to heat the air under the grates to a temperature higher than 300 deg. fahr. There are a few examples where preheated air has been used for a good many years, mostly in British-built steamships where air preheaters in the stacks have recovered a certain amount of heat. But there are certain practical objections to utilizing air at a temperature of more than 300 deg. for combustion, and one of the objects of the present paper is to describe a practical way of overcoming one of these objections.

The author's company has developed a heat interchanger at its Midland plant that operates on the same principle as the heat regenerator in the Siemens open-hearth steel furnace, except that scrap iron is used instead of brick filling. There is a great deal of old iron pipe at the plant, and this has been cut to 4- and 5-in. lengths and then piled into the heat interchanger. This pipe scrap is first heated by the stack gases, and then, through an arrangement of valves, the flow is reversed and the heat in the iron is given up to the air that goes under the grate.

There is a vertical shaft through the center of the heat interchanger that operates the valves at the rate of one revolution every seven minutes. The interchanger takes air from the furnace and discharges it into the atmosphere at about 100 deg. above the temperature of the surrounding air. Then it takes in fresh air, which recovers a very large percentage of the total heat, and carries it down into the furnace. In fact, theoretically, it can put more degrees into the entering air than it took from the outgoing gases, because of the fact that the outgoing gases contain a larger percentage of steam—due to combustion of the hydrogen in the coal.

The main feature about such an apparatus is this: Instead of absorbing the lower-temperature heat in economizers, where the Carnot-cycle efficiency with which that heat is used is only 15 to 20 per cent, the heat of the stack gases is returned to the furnace

[1] President, The Dow Chemical Company.

Presented at the A.S.M.E. session of the annual meeting of the Association of Chemical Equipment Manufacturers, Cleveland, Ohio, May 14, 1926.

to be absorbed by the boiler at the highest temperature of the cycle.

In an ordinary power plant, it is the author's experience—and that of many others—that 14 per cent CO_2 gives decidedly more trouble than 13 per cent. At 13 per cent CO_2 the heat is distributed through one-thirteenth more air than at 14 per cent CO_2, with the result that the temperature in the furnace is not as high. In the author's experience a lower power cost is obtained by running at 13 per cent CO_2 than at 14 per cent. There is a slight economy in coal consumption in going from 13 to 14 per cent CO_2, but it is more than counterbalanced by the increased repair bill.

Feeding preheated air at 800 deg. fahr. and then going to 13 or 14 per cent CO_2 in a furnace would add the 800 deg. to the temperature now attained with disastrous results. For this reason the author considers it necessary, or at least advisable, to adopt the following system of combustion.

Two-Stage Combustion. In this system, referring to Fig. 1, one-

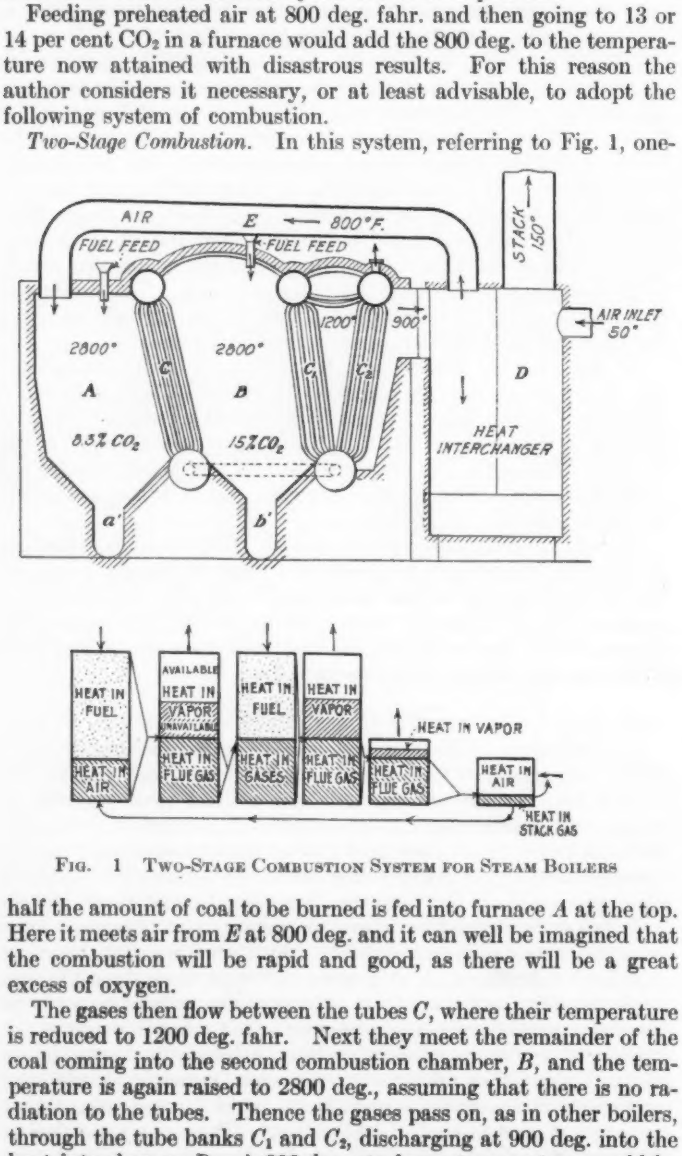

FIG. 1 TWO-STAGE COMBUSTION SYSTEM FOR STEAM BOILERS

half the amount of coal to be burned is fed into furnace A at the top. Here it meets air from E at 800 deg. and it can well be imagined that the combustion will be rapid and good, as there will be a great excess of oxygen.

The gases then flow between the tubes C, where their temperature is reduced to 1200 deg. fahr. Next they meet the remainder of the coal coming into the second combustion chamber, B, and the temperature is again raised to 2800 deg., assuming that there is no radiation to the tubes. Thence the gases pass on, as in other boilers, through the tube banks C_1 and C_2, discharging at 900 deg. into the heat interchanger D. A 900-deg. stack-gas temperature would be quite fatal ordinarily—there would be a 20 per cent stack loss; but by using the heat interchanger and bringing back most of the heat, this loss can be brought down to 2 per cent.

A two per cent stack loss seems incredible, but it has been kept down to that in one installation at the author's plant for more than a year. The latest report on a second heat interchanger was 180 deg. fahr. stack temperature, the boiler operating at 200 per cent of rating. In this case a waste-heat boiler operated at atmospheric pressure to bring the temperature down as low as possible so that the temperature of the air going under the grate would not exceed 300 deg. fahr. because the stoker builders would not guarantee their stoker if that temperature was exceeded.

In the first interchanger installation a Newman stoker is used, the coal being blown in at a height of about three or four feet above the grate. Prior to the use of heated air under the grate it was necessary to spread the coal by hand once every hour or so, because holes formed, causing low CO_2 and inefficient combustion, unless this was done. However, when the temperature of the air was raised to 300 deg., it was necessary to spread the coal only once in every eight hours. If the air were raised to a temperature of 800 deg. and the coal were dropped ten feet instead of about three feet, all the fuel would burn in suspension, even though it were not finely pulverized.

The author does not say, however, that there would not be more complications in the second combustion chamber, B, than in the first. Pulverized or partially pulverized fuel may be required, but if the temperature is 1200 deg. to start with and a generous excess of oxygen is carried, fine grinding will not be necessary. It will probably be cheaper to increase the size of the heat interchanger and run at a lower CO_2 percentage than to grind to any great extent for the second furnace.

MAXIMUM POSSIBLE EFFICIENCY OF POWER PLANTS EMBODYING ABOVE PRINCIPLES

Assume now a modern power plant with 680 lb. pressure but no superheat, using the bleeder system on the turbines to such an extent that the Rankine cycle becomes 90 per cent of the Carnot cycle. The steam temperature would be 500 deg. fahr. and the Carnot-cycle efficiency would be 44.8 per cent.

The next point is turbine efficiency, and in this assumed case it is only 75 per cent because the turbine is not working on superheated steam. (See column 1, Table 1.) As the steam expands in the turbine, water is formed, and as no one has yet found out how to

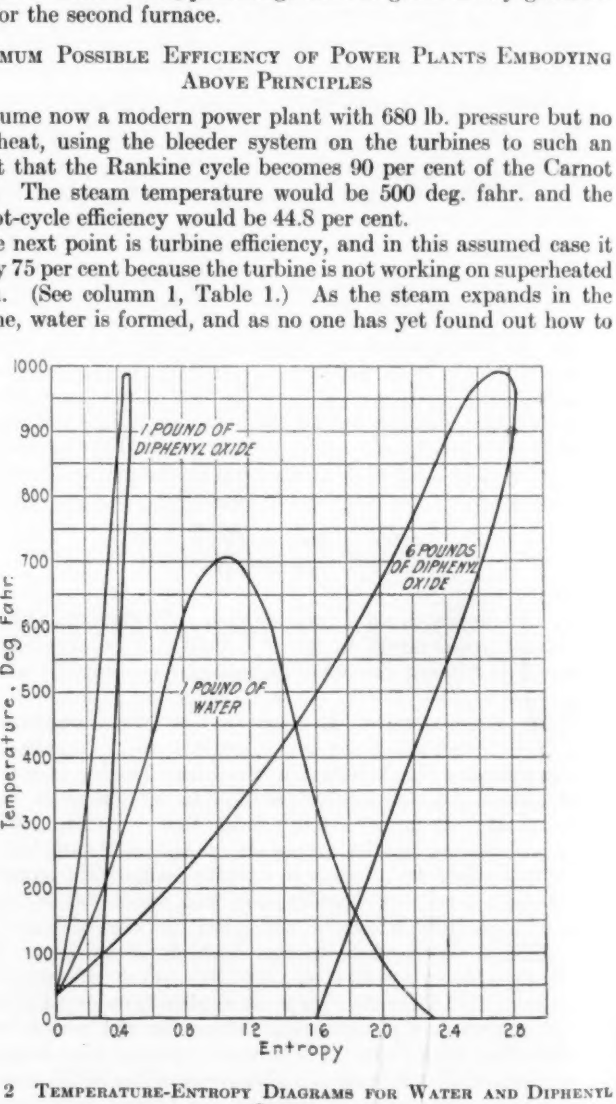

FIG. 2 TEMPERATURE-ENTROPY DIAGRAMS FOR WATER AND DIPHENYL OXIDE

TABLE 1 COMPARATIVE EFFICIENCIES OF STEAM AND DIPHENYL OXIDE-WATER POWER PLANTS

	Steam Plants		
	500 to 70 deg. fahr. (per cent) (1)	500 to 70 deg. fahr., superheat twice to 750 deg. fahr. (per cent) (2)	Diphenyl Oxide-Water, 750 to 70 deg. fahr. (per cent) (3)
Carnot-cycle efficiency	44.8	45.4	54.6
Ratio of Rankine to Carnot cycle	90	90	90
Steam-turbine efficiency	75	82	83
Generator efficiency	96	96	96
Boiler efficiency	93	93	93
Percentage of power available (Total less percentage for auxiliaries)	95	95	94
Final thermal efficiency	25.65	28.4	34.2
B.t.u. per kw-hr.	13,250	12,000	10,000
Coal per kw-hr., lb.	0.95	0.86	0.72
Oil per kw-hr., lb.	0.74	0.67	0.35

make an efficient combination water wheel and windmill, the efficiency is naturally poor. The generator efficiency is 96 per cent, which is common in big generators. The boiler efficiency is 93

per cent. This may seem too high, but it corresponds to a 2 per cent stack loss instead of one of 10 or 15 per cent, and still leaves 5 per cent for radiation, which is a fair estimate for a big boiler, so 93 per cent is not out of the way. Then there is 5 per cent for auxiliaries, which leaves 95 per cent available. Multiplying all these together will give an overall efficiency of 25.65 per cent, which is equivalent to 13,250 B.t.u. per kw-hr., or less than one pound of coal per kw-hr. These figures are entirely reasonable, every step indicated having been accomplished in one plant or another.

The second column of Table 1 gives figures for a plant somewhat similar to the Crawford Avenue plant in Chicago. In the latter plant, however, instead of the high temperature being 500 deg. fahr. corresponding to 681 lb. pressure, a pressure of 550 lb. is carried and the steam is superheated to 700 deg., and after partial use is again superheated to 700 deg. In the assumed plant for which figures are given in the table the steam is superheated in each case to 750 deg. fahr.

The only particular difference between this plant and the first one is that instead of having a 75 per cent turbine efficiency it has one of 82 per cent. This assumption is justifiable because here

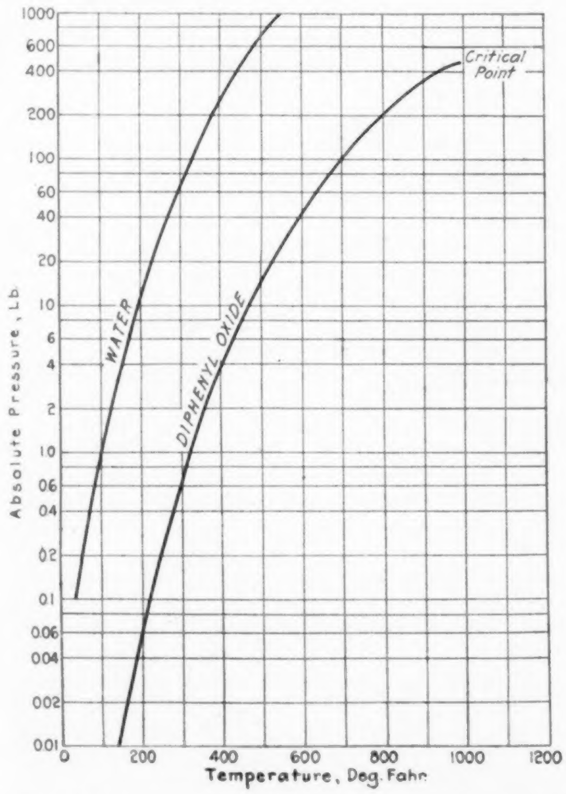

Fig. 3 Vapor-Pressure Curves for Water and Diphenyl Oxide

the wheel operates as a windmill on dry vapor all the while due to superheating and resuperheating. The result is a total efficiency of 28.4 per cent, or 0.86 lb. of coal per kw-hr.

There is no practical way of going further than this with steam alone; there is no gain in increasing the steam pressure.

If we desire to increase the Carnot-cycle efficiency by putting the heat in a steam plant at a higher temperature, say, at 2000 lb. pressure, we shall find that compared with the steam boiler where it is put in at 700 lb. pressure, there will be a gain in the Carnot-cycle efficiency of 7 per cent.

Of that 7 per cent, 2 per cent will be lost because of the larger boiler-feed pump required. This will bring the gain down to 5 per cent. There will also be a loss because of the ratio of the Rankine cycle to Carnot cycle not being 90 per cent. That is, the same proportion of investment for bleeding and preheating will not give 90 per cent, but, say, 85 per cent, if working on 2000 instead of 700 lb. pressure. That will then wipe out the remaining 5 per cent and result in no gain at all.

It can be mathematically demonstrated that there is no other method available to materially increase the above-mentioned 28.4 cent overall efficiency except by the use of a liquid that has a boiling point that is higher than that of water.

Diphenyl Oxide and Its Properties

Mercury has properties that are superior in many respects to those of any other substance. It is capable of being raised to a higher temperature than any other known liquid. Any organic material has a limit beyond which it will decompose, whereas there is no tem-

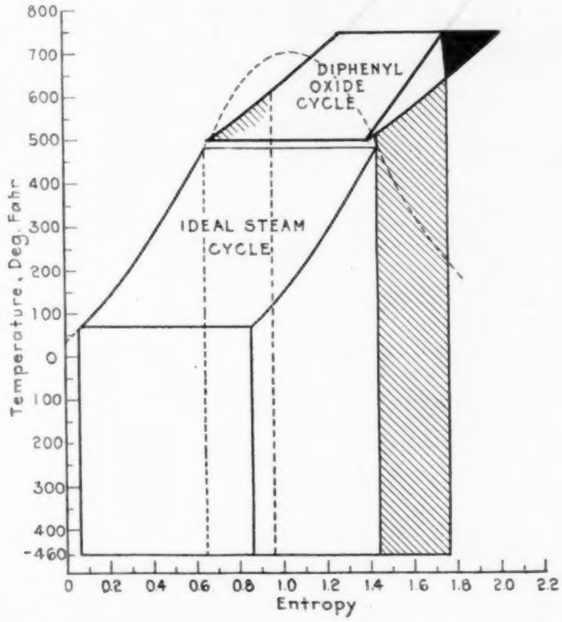

Fig. 4 Temperature-Entropy Diagram for Diphenyl-Oxide Bi-Fluid Plant

(Diphenyl oxide, 135 lb. to atmosphere; water, 600 lb. to 29¼ in. vacuum.)

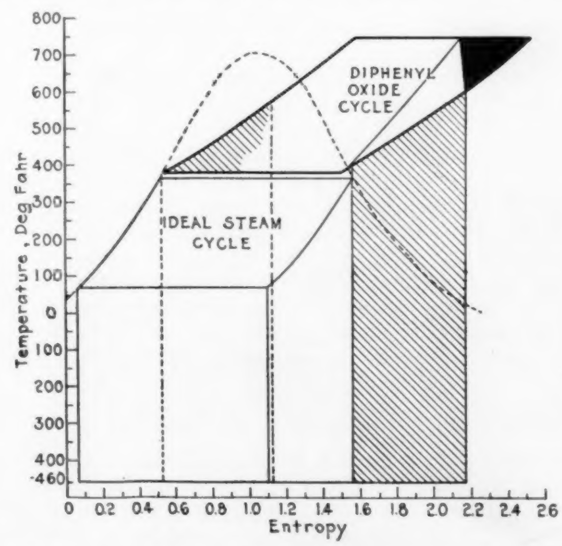

Fig. 5 Temperature-Entropy Diagram for Diphenyl-Oxide Bi-Fluid Plant

(Diphenyl oxide, 135 lb. to 24 in. vacuum, water, 150 lb. to 29¼ in. vacuum)

perature at which mercury will not be mercury. Accordingly, it has an unlimited field, if a material can be found that will hold and use it at extreme temperatures. This was clearly understood by the man who developed the bi-fluid system, Dr. Emmet. However, he failed to recognize the availability of the organic compound, which, so far as the author knows, has the highest boiling point with the greatest practicability, namely, diphenyl oxide. On the contrary, Dr. Emmet stated that it would decompose in a boiler. Now, the author's company happens to be the only manufacturer in the United States that makes diphenyl oxide on a large scale, and in its process of manufacture it employs a higher temperature than that at which Dr. Emmet thought it would decompose.

Accordingly, some of this diphenyl oxide was purified at various temperatures and it was found that it did not decompose under the proposed power-plant conditions, although it does if the temperature is made high enough, and the time long enough.

Diphenyl oxide is a white solid at room temperature, but a liquid if it contains a slight amount of impurity. It melts at 81 deg. fahr. when very pure. The fact that it is a solid is a slight objection, but any part of the boiler room where it would be used would have a temperature above 81 deg. Its specific gravity is 1.083 and its boiling point at atmospheric pressure is 258 deg. cent. or 496 deg. fahr., which is the temperature of saturated steam at 680 lb. pressure.

At 200 lb. pressure its boiling point is 800 deg. fahr. Its specific heat is approximately 0.4. Its critical pressure is 465 lb. at a temperature of 530 deg. cent. or almost 1000 deg. fahr. Another physical property not often recorded in the tables is its price. In quantity lots it is worth 30 cents a pound. It can be produced in unlimited quantities, and the cost per unit volume is less than 2 per cent of the cost of the same volume of mercury. This is one principal reason for advocating diphenyl oxide in bi-fluid power systems.

One of the thermodynamic properties of diphenyl oxide is that in an ordinary turbine where it expands adiabatically, instead of condensing like water it superheats to a marked degree, even in a 100 per cent efficient turbine. For example, when the vapor expands from 135 lb. gage down to atmospheric pressure where the boiling point is 500 deg. fahr., the temperature, instead of being 500 deg., is about 625 deg.

This extreme amount of superheating has an advantage and a disadvantage. It is difficult to transfer heat from a superheated vapor. Accordingly, when this vapor is exhausted at 625 deg. it is necessary to use it regeneratively to heat the boiler feed in order to get 90 per cent of the Carnot cycle, otherwise the efficiency of this cycle would be only 75 per cent. We have 15 per cent as the goal to be gained by using regenerative heating, that is, taking the exhaust superheat from the turbine and using it for reheating the boiler feed, which corresponds to bleeding in an ordinary steam installation. A certain amount of this can be done, but whether or not it can be brought up to 90 per cent without prohibitive expense, has not yet been demonstrated.

Another advantage of diphenyl oxide is that the weight of its vapor is about 9.4 times that of steam vapor. This means that a diphenyl-oxide turbine will run at a lower speed with higher torque for the same horsepower than a steam turbine, which is a great advantage. It may be that on that account we shall get a little higher turbine efficiency, and we shall certainly get some higher turbine efficiency by reason of the fact that there is never any condensate in the vapor.

One difference between diphenyl oxide and mercury is that the latter does not wet steel, and on this account the boiler tube may get much hotter than the mercury; whereas diphenyl oxide does wet the tube, so that it is easier to transfer the heat from the boiler to the liquid.

A Proposed Diphenyl-Oxide Bi-Fluid Power Plant

For these various reasons the author feels very confident in proposing the diphenyl-oxide bi-fluid plant working between 750 and 70 deg. fahr. The diphenyl-oxide vapor would be generated in a boiler at 135 lb. gage pressure and expanded to a vacuum depending on the steam pressure with which it is desired to work. The temperature-entropy diagrams show two such combinations, one (Fig. 4) in which the diphenyl oxide is condensed at atmospheric pressure, making steam of about 600 lb. pressure, and the other (Fig. 5) exhausting at about 24 in. of vacuum, making steam of 150 lb. pressure.

The black area in each diagram represents the difference between the Rankine and the Carnot cycle in the proposed diphenyl-oxide cycle. The saturated vapor enters the turbine at 750 deg. fahr. and expands to the exhaust pressure with a temperature considerably higher than the condensing temperature. The superheat in the vapor, represented by the shaded area, is then removed in a counterflow boiler-feed preheater. The heat of vaporization at the condensing temperature is given up to the water in the condenser boiler and the liquid diphenyl oxide is returned to the boiler through the preheater. The steam should be superheated by direct heat or by diphenyl-oxide vapor in order to gain the increase in the efficiency of the turbine.

* * * *

Following the presentation of his paper Dr. Dow replied to questions propounded from the floor. The additional information thus brought out is summarized below.

Superheating of the exhaust vapor is a thermal property of diphenyl oxide and many other organic substances. Whenever the heat put into the liquid plus the heat of vaporization is in excess of the heat that can be turned into mechanical energy by a turbine plus the total heat of the saturated vapor at the condensing pressure, the difference goes into superheat. This is the case with all liquids that had a high ratio of specific heat to latent heat. The heat that goes in as specific heat into the liquid and into the latent heat of evaporation, comes back partly as power and partly as superheat in the vapor.

As to the instability of diphenyl oxide when heated, some of it was boiled in an iron boiler for a month at 830 deg. night and day. At this temperature there was some decomposition after a month—in the neighborhood of 1 or 2 per cent. It was then boiled at 135 lb. pressure, which corresponded to 750 deg. fahr., and the decomposition decreased to a fraction of 1 per cent. Thus diphenyl oxide has actually been employed within the temperature ranges discussed in the paper.

There is some phenol formed in the diphenyl oxide, but it acts in the same way as the diphenyl oxide, except that it modifies the thermal properties to a slight extent. There is a slight amount of decomposition incident to the amount of oxygen in the system at the start, but only a fraction of 1 per cent.

As to its commercial possibilities, they are much greater where coal is high priced than where it is cheap. In the future, as coal prices get higher, it will be a much more valuable material, and more desirable, than it is now. It will also be more desirable to use it on a very large scale than on a small one.

For a given horsepower, the volume of a diphenyl-oxide boiler will be the same as that of an equivalent steam boiler. However, the former boiler is distinctly different on account of the very low latent heat of diphenyl oxide. The tubes have to be short and it is necessary to have some special means of circulation, either a circulating pump or special construction to give maximum circulation. Diphenyl-oxide vapor against hot metal surfaces would be undesirable.

Regarding two-stage combustion, the point has been raised that the difficulty of getting each particle of oxygen to come in contact with the hydrogen or carbon, or whatever it is desired to burn, will increase in the second stage because of the fact that there will be a larger percentage of inert nitrogen and carbon dioxide than in the first furnace. This is exactly what will happen. The solution is that instead of using 72 per cent of the oxygen in the air, which is done in some very economical plants, to use only 68 or even 60 per cent and correspondingly increase the size of the heat interchanger. But it must be borne in mind that when the stack loss is but 2 per cent, decreasing the CO_2 does not entail the loss that it does when the loss is 10 or 15 per cent. So it is perfectly feasible to carry a larger excess of oxygen in the second stage than it would be provided there were no heat interchanger at the end.

The stack gases may be handled with an induced-draft fan, the use of which has increased the cost of operation about 0.4 per cent in the company's Midland plant. To take care of this, it would be noticed in Table 1 that 6 per cent has been allowed for auxiliaries instead of 5 per cent.

Diphenyl oxide, has not as yet been tried in a turbine. As to heating up the turbine before starting, any turbine should be heated up, especially one operating at high temperatures. Of course, it depends on the amount of clearance, and if this is small then the turbine will have to be warmed slowly. External heating might be an advantage.

In addition to the experimental boilers used in the laboratory, a 1-hp. diphenyl-oxide boiler has been tried out with good success. Diphenyl oxide has not been found to have any poisonous effects, its present use being in the perfume industry on account of its geranium odor.

Experiments in Interior Ballistics

A Brief Discussion of the Principal Stages in the Development of Knowledge Concerning the Action of Powder in a Gun, Together with Particulars of the Latest Devices for Measuring Pressures and Projectile Velocities, and of Results Obtained in Recent Tests

By COL. W. H. TSCHAPPAT,[1] WASHINGTON, D. C.

IN THIS PAPER the author proposes to discuss briefly the principal stages in the development of knowledge concerning the action of powder in a gun. The very fact that in early times the action of powder was not understood aroused the curiosity of many who had to deal with it then. In this way its study had a considerable influence in the development of scientific thinking as we know it. However, it was many years after the invention of gunpowder and its use in cannon in European armies before any scientific attempts were made to explain the mystery of its action.

In 1702 De la Hire ascribed the action of gunpowder to the heating of the air between the grains by the heat given off by the combustion of the charge. A little later Robins in England explained correctly that De la Hire's theory could not account for the great force of gunpowder and ascribed its action to the great volume of permanent gases at the high temperature developed in the explosion.

It was not until 1793 that efforts to determine the pressure experimentally were made. These were made by Count Rumford and consisted of placing over the muzzle of a special mortar a weight which was varied until it was just sufficient to confine all of the gases after firing. The pressure represented by the weight was then considered that of the powder. As might have been expected, the pressure determined by this method turned out to be much too high, since the weight had to overcome not only the static pressure of the gases but also the kinetic or impact pressure.

In 1841, Col. George Bomford, U. S. A., devised a scheme of drilling holes through the wall of a gun at intervals of one caliber, and determining the pressure at these points by measuring the velocity imparted to steel balls placed in the holes and acting as bullets when the gun was fired. Velocities were measured with the ballistic pendulum. The thickness of wall of the columbiads in our service before the Civil War was determined in this way.

Up to this time no self-contained instrument had been developed which could be conveniently used for measuring the pressure in any gun.

Pressure Gages

Until the invention of the pressure gage by Major Rodman in 1857 and 1858, charges were largely established by empirical rules based on the results of previous experience with other guns, the limiting weight of charge having sometimes been determined by the accidental bursting of the gun. With the development of the pressure gages and of accurate velocity-measuring instruments, it became possible to break away from rigid rules as to relative weight of charge and projectile, projectile and gun, etc., and to establish a charge within the limit of pressure established for the gun, and it is to be noted that a rapid development of ordnance in both variety and size followed the development of these instruments.

Rodman's pressure gage (Fig. 1) consisted of a cylindrical housing containing a piston accurately fitted and carrying at the inner end a spear-shaped cutter g. A copper disk h was placed at the end of the housing, so that a pressure applied to the piston would force the cutter into the copper disk. The pressure applied to the piston was determined from the length of the cut made in the disk.

Rodman's gage and the experiments he conducted with it attracted a great deal of attention in Europe, and experimenters in various countries used it or modifications of it in tests. Among these was Noble in England, who used this gage in another form, and in 1863 substituted a flat piston A for the spear-shaped piston and a copper cylinder B for the copper disk. (Fig. 2.) As thus modified the gage acts by crushing or shortening the copper cylinder when pressure is applied to the piston. The pressure corresponding to varying compressions of the copper cylinder is determined in a testing machine. The Noble modification of the Rodman gage, in various forms and sizes, is in universal use today in the measurements of pressures in guns.

Velocity-Measuring Instruments—The Boulengé Chronograph

Velocity-measuring instruments went through a somewhat similar series of developments to that of pressure-measuring instruments. Before 1850 the ballistic pendulum, invented by Robins in 1765,

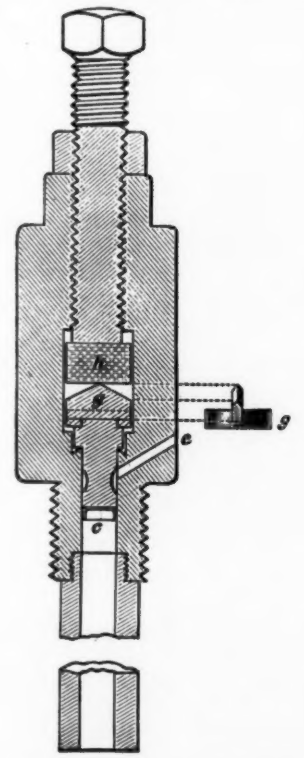

Fig. 1 Rodman's Pressure Gage

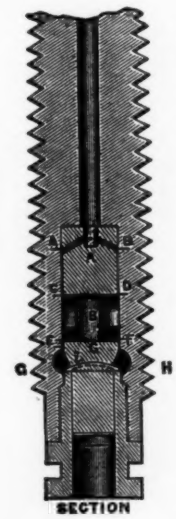

Fig. 2 Noble's Modification of the Rodman Gage

was largely used in determining the muzzle energy, muzzle velocity, and general performance of the gun and projectile. Wheatstone in 1840 first suggested the use of electricity in measuring the velocities of projectiles.

Electric velocity-measuring instruments, or rather time-measuring instruments, were found to have the greatest precision, and the Boulengé instrument, invented by Major Le Boulengé of the Belgian Army in 1869, came into universal use.

In this instrument (Fig. 3) two steel rods are suspended from two electromagnets wired respectively in series with two screens placed in the line of fire of the gun. Firing the gun breaks the circuit, (1) of the magnet holding the long rod, which then drops, and (2) of the magnet holding the short rod. In its fall the short rod strikes a trigger which releases a knife, the edge of which strikes the long rod in its fall, making a mark. The distance from this mark to another one made when both rods are dropped simultaneously corresponds to the time of passage of the projectile from the first screen to the second. From this the average velocity over the distance between the screens is computed.

The crusher gage described enables the Proving Ground to readily measure the pressure in any cannon or small arm. The Boulengé chronograph permits the measurement of muzzle velocity with a probable error of about 0.25 per cent. The question may be asked whether these instruments are not sufficient both for checking up

[1] Chief of Technical Staff, Ordnance Department, U. S. A.

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the performance of a gun and for the collection of ballistic-engineering data for use in future designs.

The Boulengé chronograph does measure velocity with sufficient accuracy to check the performance of the gun, but it is not sufficiently accurate to permit the measurement of the drop in velocity due to air resistance as the projectile goes down the range. This process involves taking the difference between two numbers each of which is subject to an error of 0.25 per cent. The percentage error in the difference may therefore be very large. Such measurements are necessary in determining the air resistance opposed to the motion of projectiles, and such determinations are always made, using improved types of velocity-measuring instruments, before any new form or type of projectile is adopted.

As to the usual methods of measuring pressure by means of the

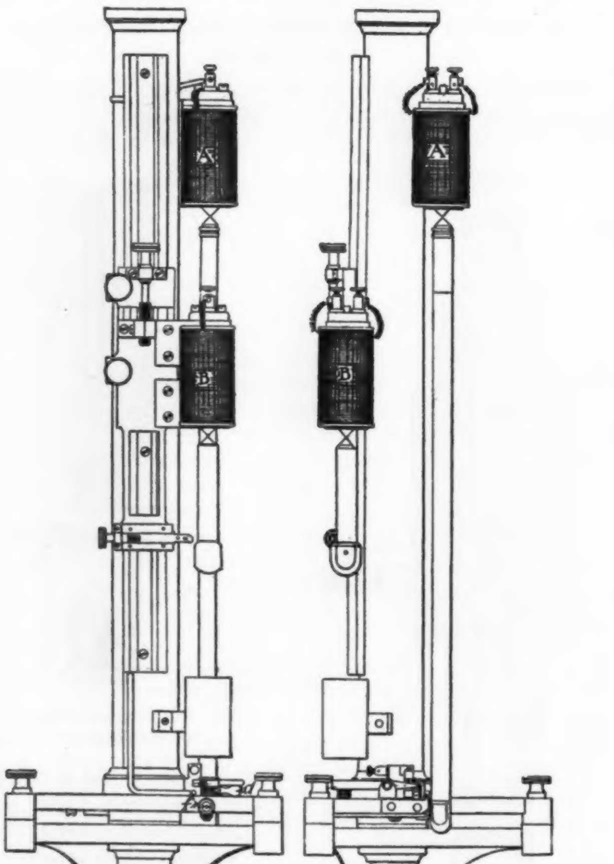

FIG. 3 THE BOULENGÉ CHRONOGRAPH AS MODIFIED BY BREGER

crusher gage described, there is no certainty that the results are accurate. In fact, they are known to vary from the true pressure by 15 to 20 per cent, and in some cases by 30 per cent. When the experiments about to be described were planned (soon after the end of the war), a good deal of consideration was given to the gun that should be used in conducting them. Certain information was then wanted in connection with new designs for artillery of all calibers proposed in a post-war program known as the Caliber Board Program. This program called for the design and development of cannon ranging in caliber from 37 mm. to 16 in., using projectiles varying in weight from 1 lb. to 2400 lb.

TESTS ON A 240-MM. HOWITZER

One of the guns built during the war and available in considerable numbers is the Schneider 240-mm. howitzer. Designed by Schneider in France, this gun was built in this country and put through proof tests at Erie Proving Ground, Port Clinton, Ohio, and at the Aberdeen Proving Ground, Aberdeen, Maryland. During the proof firing of these guns, five out of a total of several hundred blew up in the entire length from the muzzle to the end of the jacket forging. While only five of these guns actually blew up, nearly all of them expanded to some extent during proof firing, which subjected them to a pressure of approximately 30,000 lb. per sq. in. After these failures a careful examination was made of the metal of the guns and no serious defects discovered. Physical tests made of the metals indicated the same strength and ductility as the original acceptance tests of the forgings. Tests were made to determine the presence of internal stresses in the metal and such stresses were actually found, but they may have been introduced by the explosion. Later on, the theory was advanced that the form of the rifling of these guns might add additional stresses to the guns. The driving edge of the lands of these guns is not in a radial plane but is inclined in such a manner as to permit the metal of the rotating band of the projectile to ride up the land, thus causing a wedging action which tends to expand the gun. A number of these guns were rerifled so as to place the driving edge in a radial plane. The firing of these guns did not produce expansion. It was computed that the wedging action was the equivalent of about 5000 lb. per sq. in. additional powder pressure. The correction of the wedging action therefore in effect reduced the powder pressure by about 5000 lb. per sq. in., which seems to have been sufficient to prevent permanent expansion on firing. It was felt, however, that the matter was not entirely solved. A comparison of the muzzle energy of this gun per pound of weight of gun as compared with that of other guns in our service indicated a value about twice as great. It is therefore not surprising that the accidents referred to should have taken place.

The program of construction outlined by the Caliber Board required the construction of new and more powerful guns of various calibers, all of which should be as light in weight as possible. The 240-mm. howitzer was a gun which was exceedingly light in weight and which had been shown by tests to be very accurate, and it therefore became important to determine just how nearly the relative lightness of this howitzer could be approached in these new types of guns, and still maintain a satisfactory factor of safety.

PROGRAM OF EXPERIMENTAL WORK ON 240-MM. HOWITZER

The program for experiments on the 240-mm. howitzer was outlined in 1921. Its purpose was:

- *a* To determine the actual pressure at all points in the bore of the howitzer
- *b* To determine the velocity of the projectile along the bore of the howitzer, and for some distance in front
- *c* To determine the actual maximum expansion at all points in the bore of the howitzer during firing
- *d* To obtain additional knowledge as to ignition of the powder charge
- *e* To obtain additional knowledge as to calibration of pressure gages and methods of recording pressures in cannon.

To make more clear just what information it was desired to obtain in this ambitious program, the records desired were listed as follows:

- *a* Record of time-travel of projectile in the howitzer and for some distance in front
- *b* Record of time-pressure in the howitzer, using the Curtis and the piezoelectric time-pressure gages
- *c* Record of travel-pressure in the howitzer, using suitably placed pressure gages
- *d* Record of time-free-recoil of the howitzer and connected parts
- *e* Record of instant of ignition of the charge
- *f* Record of time of starting of the projectile
- *g* Record of travel-expansion or time-expansion of the outside of the howitzer during firing.

The program provided for firing five rounds under one set of conditions of loading, and for obtaining simultaneously as many of the above records for each round as possible. It is to be noted that with the exception of (*g*), similar records had in past times been obtained in various ways. It is thought, however, that the program outlined is the most complete one of this nature ever undertaken, in that it provided for the *simultaneous* measurements of pressures, velocities, displacements, and times at each round. This made it possible to check results obtained by one method against those obtained by another method, for the same round, thus making

it easy to detect and correct errors. Also, it was thought that the proposed experiment, including as it did time-pressure records and expansion records of the gun, would give information additional to any that had been obtained heretofore. Further, it was felt that some of the new instruments which were to be used were capable of giving results of greater accuracy than any that had heretofore been obtained.

The Piezoelectric Pressure Gage

One of these instruments is the piezoelectric pressure gage, which is based on the characteristic of many crystals that when compressed along certain main axes a charge of electricity is developed. The first survey of a scheme for the construction of such a gage in this country was conducted by Dr. G. F. Hull, then Major, Ord. Dept., in 1919. The work done by him was later turned over to the Bureau of Standards where development progressed under Dr. E. A. Eckhardt and J. C. Karcher and gages based upon this principle were constructed. A number of these gages were used in the experiments with the 240-mm. howitzer at the Aberdeen Proving Ground, and the faults found with the original gage gradually corrected. Fig. 4 shows the housing and elements of the gage. The quartz disks of this gage were constructed by the Bureau of Standards on an optical grinding machine. It is necessary that the flat surfaces of the disks be exactly parallel, as if otherwise constructed the disks are extremely subject to breakage under high pressure and

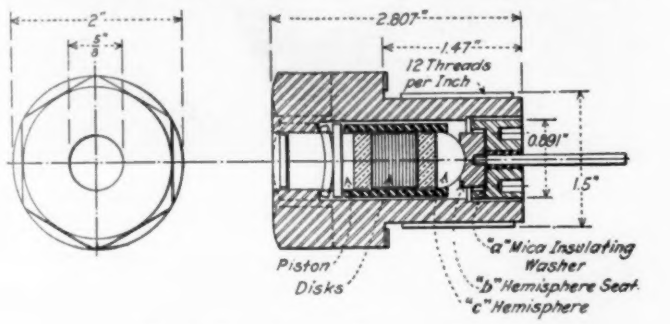

Fig. 4 Piezoelectric Pressure Gage

do not maintain their calibration. If properly assembled the pile of disks will stand the surprisingly high pressure of 50,000 lb. per sq. in. The disks should be cut from the original quartz crystal in such a direction that the maximum or nearly the maximum electric effect is produced. The electric effect produced by the same pressure should be as nearly as possible the same for all the disks assembled in one gage. If this is not the case, the constancy of the calibration may be affected.

As shown, the disks are assembled in the gage with alternately positive and negative faces in juxtaposition and are separated by thin metal plates. Of the latter the positive are connected at one side of the gage and the negative at the opposite side. One set of plates is grounded on the housing of the gage and the other metallically connected to the insulated wire which projects through the end of the gage. The disks are placed in a bakelite container which is closed at each end and sealed with beeswax so as to prevent the entrance of moisture or oil, the presence of either of which will seriously interfere with the action of the gage. The connections to the housing and lead-out wire are through the metal closing disks at the ends of the bakelite container. The function of the ball joint formed by the hemispherical metal piece at one end of the gage is to prevent any cross strain or any unequal strain on the pile of disks. Fig. 5 is a phantom photograph showing the assembly. The action of the gage itself is quite simple. The pressure of the powder gas on the piston is directly transmitted to the pile of disks. It there develops a charge of electricity which is proportional to the pressure applied. In the present experiment the charge developed by the pressure was measured by leading it through a long-period galvanometer of high sensitivity, arranged with a mirror which reflects a beam of light to a rotating drum carrying a film. The passage of the charge through the galvanometer deflects the mirror and the beam of light, thus making a record on the film. Simultaneously, timing lines one thousandth of a second apart are obtained on the film by a method to be described later. Fig. 6 shows a record.

It was shown mathematically by Karcher that the deflection of the beam when the apparatus is arranged as described is proportional to the integral of the pressure and the time.

Calibration of the gage when hooked up to the galvanometer is effected by applying hydraulic pressure to the piston in a testing machine so arranged that the pressure can be suddenly released. Since the release of the pressure has the same electric effect as its application would have, it is possible in this manner to construct a "tarage curve," which in fact is a right line, showing the relation between the pressure and the deflection of the galvanometer.

The Solenoid Chronograph

Another instrument which bears an important part in this test

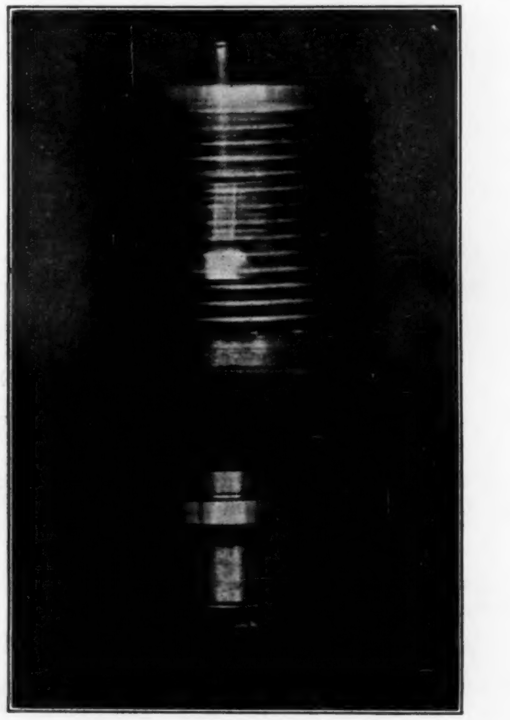

Fig. 5 Phantom Photograph Showing Assembly of Piezoelectric Gage of Fig. 4

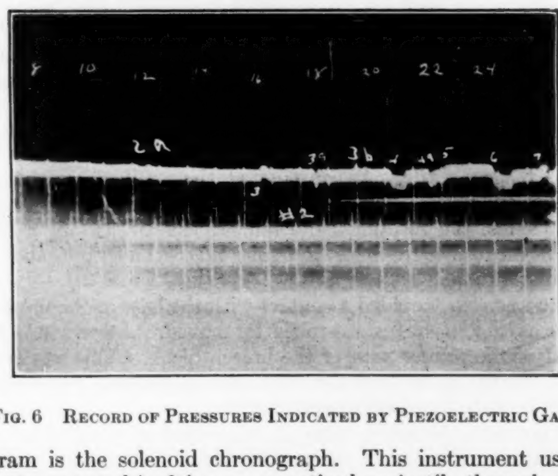

Fig. 6 Record of Pressures Indicated by Piezoelectric Gage

program is the solenoid chronograph. This instrument uses the current generated in firing a magnetized projectile through coils of wire to record on a moving film the times of passage of the projectile. The camera carrying the moving film is the same as that which records the deflection of the galvanometer of the piezoelectric gage. The current is carried from the coils through the element of a General Electric oscillograph and the deflection indicated photographically on the film. Timing lines are produced on the film by the vibrations of a tuning fork the tines of which carry metal plates having slits which overlap and thus permit the passage of light to the film twice during a cycle (Fig. 7). Satisfactory operation requires a power-operated fork and use is made of the vacuum

tube in effecting a power drive without disturbing the natural time of vibration of the fork.

Actual use of the solenoid chronograph at the Aberdeen Proving Ground since 1921 in measuring the velocities of projectiles has suggested many changes in details of the instrument. Careful balance in the electric circuit was found to be necessary to insure that the deflection of the beam of light followed as nearly as practicable, without lag or lead, the e.m.f. produced when the projectile passed through the coil. To permit accurate reading of times, it was also necessary that the deflection be strong enough to make the trace on the film at the deflection points as nearly as possible normal to the direction of its motion.

Tests have shown that as a time-measuring instrument the solenoid chronograph has about ten times the precision of the Boulengé chronograph, which is now the standard at most proving grounds.

Fig. 8 shows the use of this chronograph in measuring times to several points down the range, and Fig. 9 shows an arrangement for measuring velocities when firing at high angles. In this case the distance between the two coils is 15 ft. The accuracy of

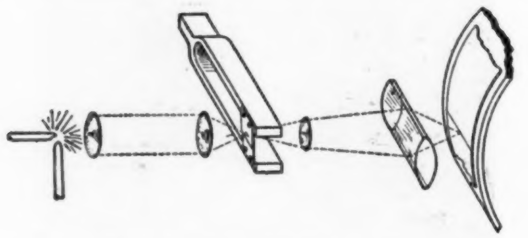

Fig. 7 Tuning-Fork Arrangement for Producing Timing Lines on Film

results is the same as when the distance between screens is 150 ft. when the Boulengé instrument is used.

Set-up of Gun and Auxiliary Apparatus

The gun was mounted on rollers on horizontal side rails so that it would move with the minimum of friction. Its motion in recoil was stopped by a hydraulic buffer which did not come into play until the gun had recoiled several feet and was no longer subject to the action of the powder gases. Figs. 10 and 11 give a general view of the gun in place. The gun was tapped at 13 places along its length for the insertion of contacts with the projectile band as it passed along. It was also tapped at 11 places along its length for the insertion of pressure gages, as shown in Fig. 12. To counteract the weakening of the chase of the gun due to the drilling of these holes and also to provide a better support, rings were shrunk over that part of the gun as shown. Fig. 13 shows in more detail the construction of the contacts and pressure gages. It was necessary of course that the contacts be insulated from the body of the gun and that the contact be made with a definite part of the projectile. As constructed, the small copper tip of the contact projects slightly into the groove of the rifling. As the projectile passes, the rotating band touches this tip, closing a circuit through the oscillograph of the solenoid chronograph and thus recording the time on the film.

There was also provided a contact with the base of the projectile, which was broken the instant the latter moved. A fine wire was led in front of the primer vent of the breech block. This was broken by the powder gases and the time of its breaking was recorded through leads to the oscillograph.

The contacts described were all connected in parallel to wires leading to one element of the oscillograph.

The record appears on the film as successive sharp deflections in the trace made by the beam of light from the mirror of that element. A record is shown in Fig. 6. In addition to the pressure gages for which provision was made in the walls of the gun, the "mushroom head" of the breech block was tapped to receive the piezoelectric and other types of pressure gages. Three can be used at each round. Provision was made for lead-out wires through the breech block.

To get a record of the recoil a contact bar having insulated contact pieces was bolted to the side frame parallel to the direction of motion of the gun in recoil. (See Fig. 11.) A metal contact finger recoiling with the gun completed circuits successively through the contact pieces and the oscillograph. This gave a record of time corresponding to known distances of recoil.

Finally, solenoid coils were erected at close intervals in front of the gun as shown in Fig. 8 so that time-travels could be determined and velocities computed not only within the gun but also for some distance in front. One purpose of this was to determine the effect of the gases on the gun and projectile after the exit of the projectile.

Results Obtained in Tests

Using a set-up similar to that indicated, a total of 22 rounds has

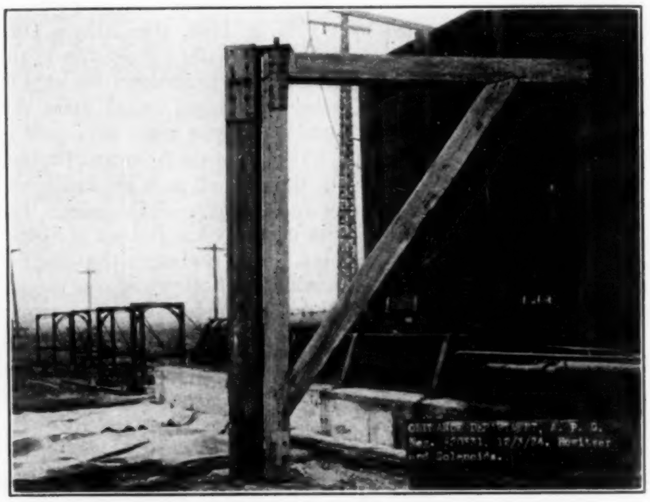

Fig. 8 Showing Use of Solenoid Chronograph in Measuring Times to Several Points Down the Range

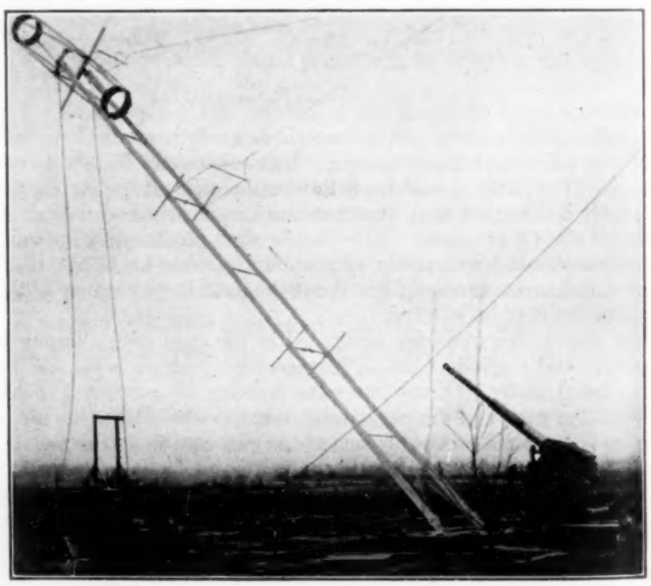

Fig. 9 Arrangement for Measuring Velocities when Firing at High Angles

been fired since the experiment was started. The early rounds were used largely to perfect and adjust the instruments, but valuable information concerning the action of powder in a gun has been obtained from nearly every round.

Two differentiations of the experimental recoil-time curves will determine the accelerating pressure on the face of the breech block. Similarly, two differentiations of the experimental projectile travel-time record will give the accelerating pressure on the base of the projectile. This should be less than the accelerating pressure on the breech block as gas and unburned powder equivalent to the weight of the original charge are also being accelerated in the direction of the projectile. On the other hand, the pressure given by a time-pressure gage placed in the breech will generally be greater

than that worked out from the experimental recoil-time curves, since it records not only the accelerating pressure but also the pressure required to overcome the friction of the projectile.

To illustrate this, there is shown first in Fig. 14 the deflection-film travel curve actually obtained in one round from the piezoelectric record. Since the film travels at a uniform speed this may be considered the deflection-time curve, its ordinates being the integral of pressure and time. When the curve is differentiated

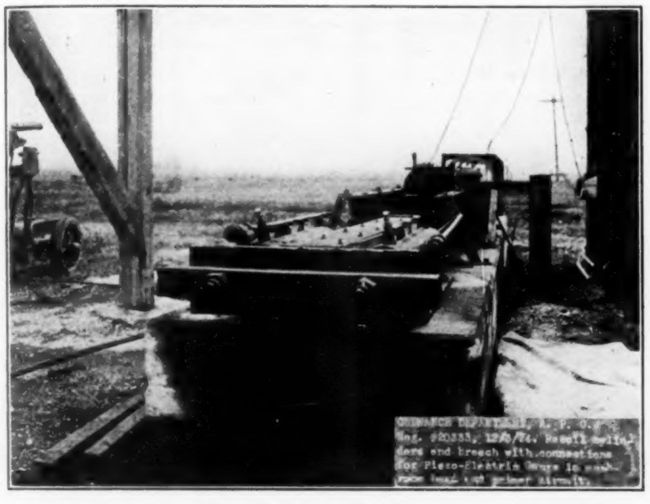

FIG. 10 RECOIL CYLINDERS AND BREECH OF GUN WITH CONNECTIONS FOR PIEZOELECTRIC GAGE IN MUSHROOM HEAD AND PRIMER CIRCUIT

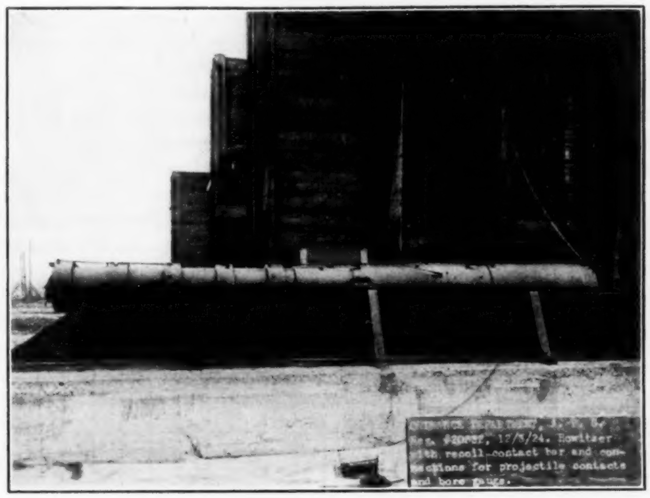

FIG. 11 GENERAL VIEW OF GUN IN PLACE

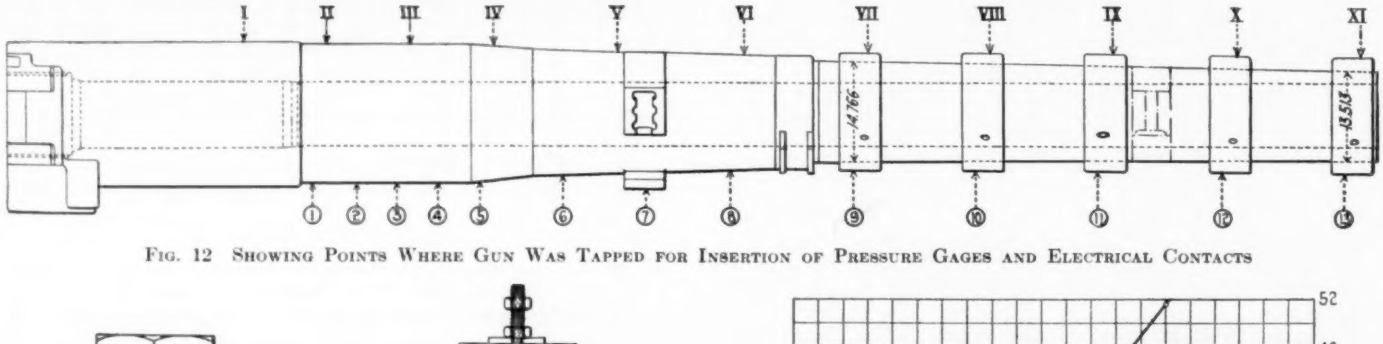

FIG. 12 SHOWING POINTS WHERE GUN WAS TAPPED FOR INSERTION OF PRESSURE GAGES AND ELECTRICAL CONTACTS

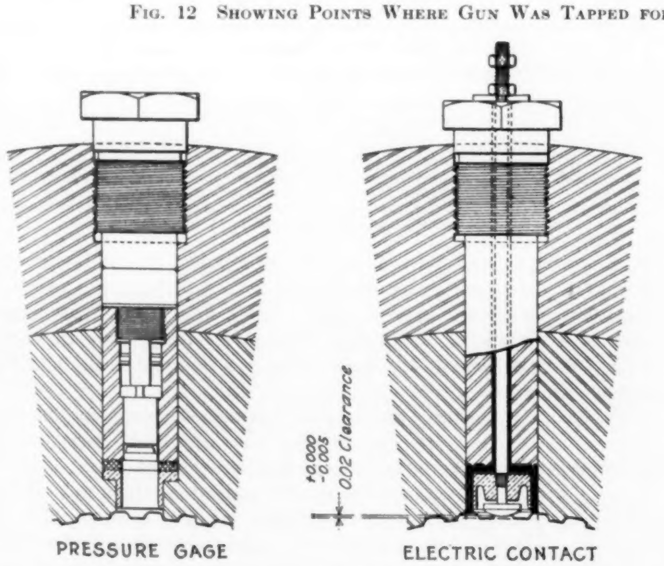

FIG. 13 DETAILS OF CONSTRUCTION OF CONTACTS AND PRESSURE GAGES

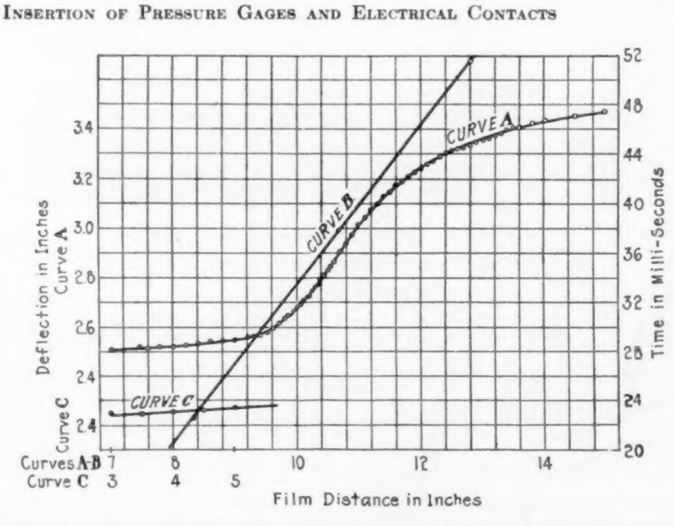

FIG. 14 DEFLECTION-FILM-DISTANCE CURVES OBTAINED IN ONE ROUND FROM PIEZOELECTRIC RECORD—240-MM. HOWITZER ON FREE-RECOIL CARRIAGE

(Weight of projectile, 355 lb.; weight of charge, 14 lb. 8 oz.; web thickness, 0.036 in.)
Curve A—Deflection-film-distance curve (7 to 15 in.), piezoelectric gage No. 3
Curve B—Time-film-distance curve
Curve C—Deflection-film-distance curve (3 to 5.5 in.).

once by the construction of tangents we obtain Curve A on Fig. 15, which is the pressure-time curve. Curve B in this figure is the pressure computed by two differentiations from the recoil contact time records. Note that it is below curve A. Having the projectile contact time records, we readily pass from the pressure-time curves to the projectile travel records, or in other words, we get the pressure along the gun as the projectile passes through. This is the most important result obtained so far as the design of the gun is concerned.

The travel records for round 20 obtained in various ways are shown in Fig. 16. It should be noted that the curve obtained by recoil contacts is consistently higher than that obtained by projectile contacts and that the one obtained by the piezoelectric gage is higher than either. The difference between it and the first curve is in this round about 1800 lb. per sq. in., which may be considered the frictional resistance of the projectile. The difference between the ordinates of curve A and curve C varies considerably, but is about 600 lb. per sq. in. for a large part of the travel. This is the pressure at the breech which drives forward the powder gases. The black dots in Fig. 16 are the pressures recorded by the crusher gages placed at corresponding points along the gun. Those placed on the first ordinate are the pressures in the powder chamber of the gun and average around 19,000 lb. per sq. in., against 22,600 com-

puted from recoil contacts and 24,400 given by the piezoelectric gage. In general, the piezoelectric gage registers 20 per cent greater maximum pressure than a copper-cylinder gage placed in the powder chamber where the quickness of action of the powder is about as it was in this round. With slower powder the percentage of excess is less, and with quicker powder, greater. In front of the initial position of the projectile and all the way to the muzzle, the crusher gages indicate pressures, in general much higher than those indicated by the piezoelectric gage. This is accounted for by the sudden application of the gas pressure to these gages as the band of the projectile passes them. The same result was obtained in every round fired from this gun when banded projectiles were used. The effect of a suddenly applied pressure in crushing the copper cylinder should be twice that of a very gradually applied pressure of equal amount, assuming that the law of resistance of the crusher copper is the same in both cases. While such a ratio has not been reached in these experiments, there are a number of cases where the

TABLE 2 RÉSUMÉ OF RESULTS OF FIRINGS OF 240-MM. HOWITZER ON FREE-RECOIL CARRIAGE

Round	Weight of projectile, lb.-oz.	Weight of charge, lb.-oz.	Web thickness, in.	Maximum pressure from coppers in breech I. C., and their initial compressions, lb. per sq. in. × 10^{-3}	I. C.	Maximum pressure from coppers along bore O. I. C., lb. per sq. in. × 10^{-3}	Time from firing of primer to start of projectile, milli-seconds	Starting resistance, lb. per sq. in. × 10^{-3}	Average resistance (distance), lb. per sq. in. × 10^{-3}	Value of exponent n of rate of burning $\left(\frac{dM/dt}{S} = KP^n\right)$
12	357–2	3– 0	0.0234	...	..	3.9	48.819	<0.5	..	...
13	360–0	10– 0	0.0234	...	..	17.2	....	<0.5	..	...
14	358–10	12– 8	0.0234	16.7	14	22.5	....	<0.5	..	...
15	354–13	16– 8	0.0234	22.35	18	30.1	....	<0.5	..	...
16	354–0	21–10	0.0234	30.7	24	55.2	....	<0.5	..	...
17	358–0	21–10	0.0234	31.34	24	49.5	....	0.7	0.75	0.754
18	354–0	10– 0	0.036	...	..	11.5	31.591	0.5	1.00	0.703
19	355–0	14– 8	0.036	...	..	19.2	....	<0.5	1.14	0.790
20	358–8	20–15	0.036	18.8	14	30.5	....	<0.5	1.35	0.940
21	355–8	25– 0	0.036	23.65	18	35.3	....	0.6	1.48	...
								Mean..........		0.80
								M. D..........		0.075
								P. E. of mean...		0.032

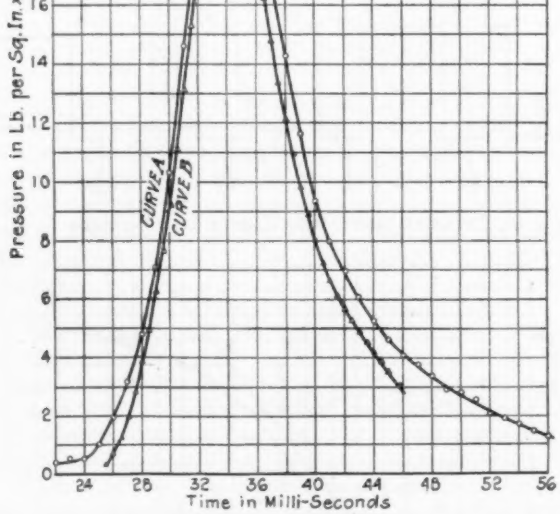

FIG. 15 PRESSURE-TIME CURVES—240-MM. HOWITZER ON FREE-RECOIL CARRIAGE, ROUND 20

(Weight of projectile, 358 lb. 8 oz.; weight of charge, 20 lb. 15 oz.; web thickness, 0.036 in.).
Curve A—Piezoelectric gage No. 3
Curve B—Computed from recoil velocities given by recoil contacts.

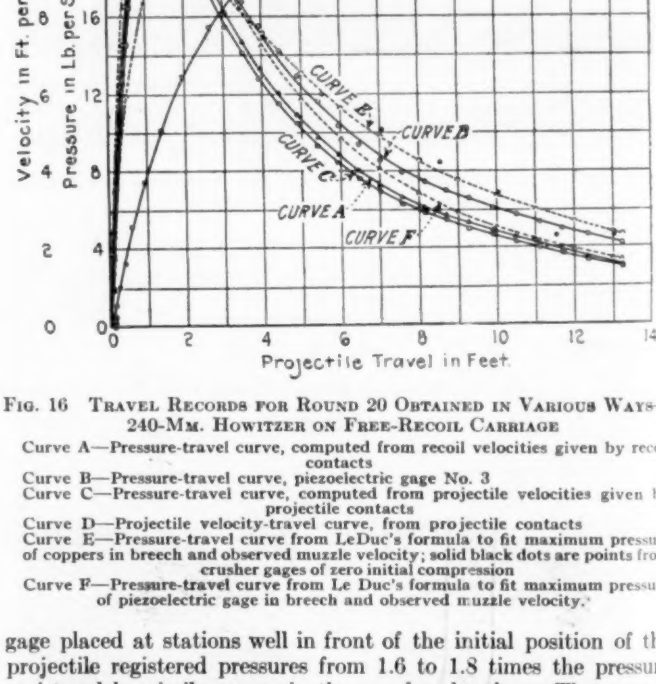

FIG. 16 TRAVEL RECORDS FOR ROUND 20 OBTAINED IN VARIOUS WAYS—240-MM. HOWITZER ON FREE-RECOIL CARRIAGE

Curve A—Pressure-travel curve, computed from recoil velocities given by recoil contacts
Curve B—Pressure-travel curve, piezoelectric gage No. 3
Curve C—Pressure-travel curve, computed from projectile velocities given by projectile contacts
Curve D—Projectile velocity-travel curve, from projectile contacts
Curve E—Pressure-travel curve from LeDuc's formula to fit maximum pressure of coppers in breech and observed muzzle velocity; solid black dots are points from crusher gages of zero initial compression
Curve F—Pressure-travel curve from Le Duc's formula to fit maximum pressure of piezoelectric gage in breech and observed muzzle velocity.

gage placed at stations well in front of the initial position of the projectile registered pressures from 1.6 to 1.8 times the pressure registered by similar gages in the powder chamber. These gages were still within the maximum pressure zone and were therefore subjected to essentially the same actual gas pressure as those in the powder chamber.

To secure uniformity in the later firings the copper cylinders used were of the "uncompressed" variety. In some of the earlier firings "compressed" coppers were used in the openings along the gun. These are copper cylinders initially compressed in a testing machine to within a few thousand pounds per square inch of the pressure expected. When such cylinders were used the pressure recorded by them was very materially lower than that recorded by the uncompressed coppers, and therefore more nearly the true pressure as determined by the methods described. Some of the interesting results obtained in the last ten rounds are given in Tables 1 and 2. These experiments are conducted at the Aberdeen Proving Ground as "fillers in" in connection with other work, or on days when weather condi-

TABLE 1 RÉSUMÉ OF RESULTS OF FIRINGS OF 240-MM. HOWITZER ON FREE-RECOIL CARRIAGE

Round	Weight of projectile, lb.-oz.	Weight of charge, lb.-oz.	Web thickness, in.	Velocity of projectile extrapolated back to muzzle from solenoids, ft. per sec.	Value of resistance coefficient C_R × 10^{-3}	Maximum velocity of recoil, ft. per sec.	Average exit velocity of powder gases computed from recoil velocity, ft. per sec.	Maximum pressure computed from recoil data, lb. per sq. in. × 10^{-3}	Maximum pressure computed from projectile contacts, lb. per sq. in. × 10^{-3}	Maximum pressure computed from piezoelectric gage, lb. per sq. in. × 10^{-3}	Maximum pressure from coppers in breech O. I. C., lb. per sq. in., × 10^{-3}
12	357–2	3– 0	0.0234	..	..	9.4	..	3.24	3.22	4.12	3.2
13	360–0	10– 0	0.0234	871	35.2	..	..	10.60	...	15.42	11.8
14	358–10	12– 8	0.0234	986	..	..	..	...	...	17.7	15.25
15	354–13	16– 8	0.0234	1169	..	..	..	...	...	26.7	21.4
16	354–0	21–10	0.0234	1361	28.2	..	..	...	...	38.2	30.7
17	358–0	21–10	0.0234	1348	44.6	..	..	...	38.0	39.9	30.25
18	354–0	10– 0	0.036	822	35.7	19.6	4082	...	9.25	10.80	7.7
19	355–0	14– 8	0.036	1021	85.3	24.65	3782	12.93	12.00	14.20	11.6
20	358–8	20–15	0.036	1270[1]	..	25.7	..	22.6	21.75	24.4	18.95
21	355–8	25– 0	0.036	1406	74.2	37.2	5197	...	26.0	28.2	22.9

[1] Approximate.

tions do not permit of other tests. The results already obtained should give the designer of a new cannon considerably more confidence as to just what stresses he needs to provide for. Improvements have recently been made in the method of recording the charge on the piezoelectric gage. The developed voltage is now applied to a vacuum-tube amplifying system in much the same way the signal is received in a radio set. The amplified current is passed through a very high-frequency oscillograph (8000 cycles per second) and recorded on a rotating film as before. By this new method the deflection of the beam is directly proportional to the pressure. Fig. 17 shows the set-up of the gage for measuring pressures in a shotgun, and Fig. 18 the actual record of pressure and time recorded in a shotgun. The maximum in this

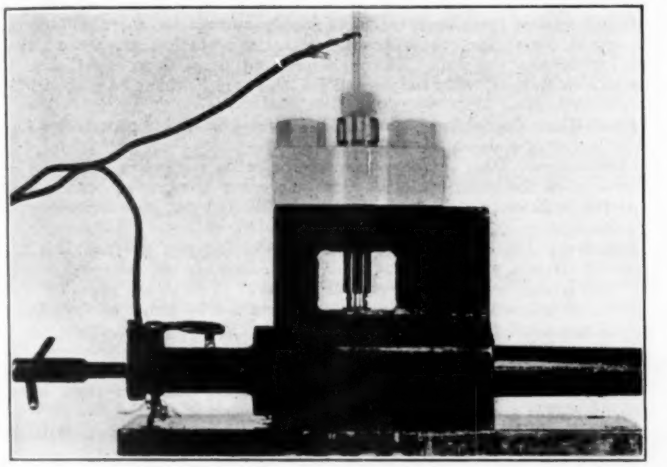

Fig. 17 Set-Up of Piezoelectric Gage for Measuring Pressures in a Shot Gun

case was about 7000 lb. per sq. in., and the pressure lasted about 0.001 sec.

The principle of the piezoelectric gage is also being applied in a blast meter intended to measure the shock of an explosion or the discharge of a gun.

Another use of the instrument is in measuring the trunnion reaction of a gun. It is especially important for this to be known for guns to be mounted on aircraft.

Finally—and this is of especial interest to scientific men—the new method of measuring instantaneous pressures in guns has made possible the collection of accurate data on the action of powder gases at pressures and temperatures which cannot easily be obtained except in guns or explosion chambers of equal strength.

Discussion[2]

THE experiments so carefully described by Colonel Tschappat are of interest to all the scientific world, not because something new has been discovered, but because a new way has been found to measure more accurately and much more conveniently the operation of our well-known laws at high speeds and great pressures.

With the quartz gage, carefully calibrated under the direction of Mr. Kent at Aberdeen, we are now able to evaluate, with little error, the total work of each charge of powder in the cannon and the rate of that work. This enables us to compare rounds of ammunition as to uniformity in the cannon; to compare different lots of powder, different kinds of powder, different weights of projectiles, different kinds of projectiles, different forms of ignition, and different shapes of powder grain.

Besides desiring to know the variations due to ignition, we want to know the effect of the movement of powder grains in the bore and how much work is consumed in this movement. It is also desired to know the effect of wear and coppering in the bore, that is, the variable resistance the projectile will encounter in going down the bore, the balance or dimensions or weight of the projectile in its final effect, the effect of the character of the rifling, the lack of straightness of the bore, and a lot of other little things which bother us in trying to make each projectile leave its projector with the same intentions. If we are able to evaluate these things, we shall be able to partially eliminate them, or, knowing them, to make allowances for them in our settings of sights and azimuths.

When these things are accounted for, the effort of battle is reduced. At the present time, our probable errors are great. If it requires twenty rounds now to secure a direct hit on an object to destroy it on the battle field, and if as a result of our research, we reduce this number to ten rounds, we shall have saved not only the manufacturing cost of ten rounds of ammunition, but all the effort of transporting them, under wartime difficulties, from the factories to the breech of our cannon, a long distance away on the battle field. We shall have saved many man-hours and have sent many more men to put their human direction and power against the enemy.

Due to radio developments, we have been able to use small currents in determining velocities; have been able to fire through coils of wire, and the breaking of lines of force through these coils has set up minute currents which can be stepped up to operate the Aberdeen chronograph. This allows us to fire continuously through two coils of wire at known distances apart, without any effect whatever on the flight of the projectile, and to read continuously the initial velocities.

By setting up cardboard screens the Proving Ground has gone ahead to determine the actual deflection of a projectile out of its curved trajectory and to measure the energy wasted by such wabbling flight. It has been able to redesign its projectiles to the greatest maximum ballistic efficiency, and the end of this experiment has not yet been reached.

A new problem has just been started to research the question of ignition, and there we have room for wide improvement.

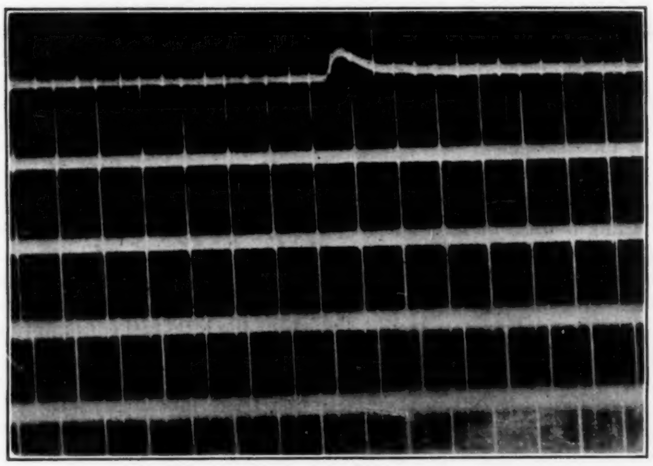

Fig. 18 Piezoelectric-Gage Pressure and Time Record for Shot Gun

In the automotive field there is much to be learned at Aberdeen through research, much that the commercial world is too busy to obtain in its accumulation of profits, but that would pay us huge dividends in the operation of vehicles on the battle field. Such things, for instance, as fitting the prime mover to its proper load, for this power of the prime mover under various conditions and the pull of the load under similar conditions must be determined. The adjustment, the fueling and oiling of the prime mover for maximum power and for maximum dependability on the battle field must be accurately determined. The simple determination of the power losses in any mechanism gives us the opportunity, not only for the improvement of the mechanism, but for determining its range of dependability.

We have a great mechanical laboratory gradually growing into importance at the Aberdeen Proving Ground, which has not yet won a name for itself, but which, nameless as it is, has already shown us the way to improvement and dividends. In coöperation with the metallurgical laboratory at Watertown Arsenal and the explosive laboratory at Picatinny Arsenal, we are in a fair way to begin research into problems which should greatly cheapen the cost of security for the United States. We need encouragement in this work and understanding of its values by our engineers.

[2] Comment on Colonel Tschappat's paper by Major C. G. Mettler, Ordnance Department, U. S. A. Mem. A.S.M.E.

Auxiliaries for Motor Vessels—II[1]

An Analysis Showing That Certain Types of Vessels Can Be Built and Operated with More Profit Than Others, and Disclosing Reasons Why a Searching Investigation of Ships' Economies Should Be Made When Selecting the Type of Machinery

By JOHN W. MORTON[2] and A. B. NEWELL,[3] CAMDEN, N. J.

As the fuel consumption per indicated horsepower of the steamship decreases, there is an increase in the number of necessary auxiliaries. We may take as an example the older ships with Scotch boilers and triple-expansion engines and compare them with a ship equipped with high-pressure, superheated-steam turbines. The difference is at once apparent. The tendency with motorships is the other way. Conservative methods demand simplified practice, and additional auxiliaries would tend toward complication. The solutions of the opposite trend in the two different methods of ship propulsion are prompted, however, by the same object, namely, reduced cost of operation.

Steamships must effect greater fuel economy in order to compete successfully with motorships on long voyages, for, as the result of long periods of continuous operation, they must shut out cargo to make room for fuel. On the other hand, the motorship must reduce the capital charges to compete successfully in short hauls, where the question of shut-out cargo may be almost neglected. Time in port must either be charged to cargo handling or to profit and loss. To carry expensive equipment which is not needed, costs dearly.

In short, the steamship must reduce fuel consumption and the motorship must reduce the initial cost. In the first instance more auxiliary machinery seems necessary, while in the second, less seems essential. The figures involved may be summarized as follows:

Depreciation	5 per cent
Interest or profit on investment	8 per cent
Insurance	5 per cent
Repairs and maintenance	2 per cent

making a total of 20 per cent per year on the difference in cost. This figure must not be overlooked when thinking of a 60 per cent saving in cost of fuel for the motorship. The 20 per cent continues whether the ship runs or not and represents a fixed amount, whereas the 60 per cent changes almost directly as the total fuel consumption changes upon the vessel entering or leaving port.

For a number of years motorships were looked upon in America as experiments. When they were first tried, investors resorted to a number of foolish expedients hoping to reduce the first cost. The cheapest, and consequently poorest, auxiliaries were purchased. Sometimes second-hand steam machinery was crammed into the engine room regardless of adaptability or space occupied. Needless to say, grief resulted.

Engine-Room Auxiliary Machinery

The tendency now is to follow more mature methods of European builders, with certain modifications which we may call Americanizations. Thus the engine-room auxiliary machinery of freight motorships of from 5000 to 10,000 tons deadweight capacity have been reduced almost to a standard, so nearly so at least that the following list may be considered as representative of the average.

Pumps

Service	No. of units	Type
1 Main cooling water	2	Centrifugal (generally)
2 Piston cooling water	1	Plunger
3 Lubricating oil	2	Rotary or plunger
4 Fuel-oil service	1 or 2	Rotary or plunger
5 Bilge and ballast	1	Plunger
6 Engine-room bilge	1 or 2	Plunger
7 Sanitary	1	Plunger or centrifugal
8 Fresh water	1	Plunger

Generating Sets. Generators driven by small oil engines, not less than two and seldom more than three, to supply current for the auxiliary machinery in the engine room, steering gear, deck winches, anchor windlass, and for lighting the ship. The maximum output of these is sufficient for the maximum load, while the normal sea load may be taken care of with but one.

Fresh-Water Cooler for Piston-Cooling Service. Similar to a boiler feed-water heater or a steam condenser.

Compressors. One auxiliary compressor with a capacity slightly less than that of the main engines. One emergency compressor with a small capacity, sufficient to charge a starting bottle and put a generating set in operation.

Emergency Lighting Set. If steam is used for any purpose this may be steam driven, with sufficient capacity for lighting the ship and running the bilge pump, or the emergency compressor. If no steam is used a small gasoline or kerosene engine which may be started by hand, and which has a similar capacity, is employed.

Heating Plant. A small oil-fired boiler, sometimes so arranged that exhaust gases from the main engines will generate steam while at sea.

Water Traps and Feed Tanks. Where a closed heating system is used with no steam machinery employed no condenser is needed.

Boiler-Feed Pump. Generally electrically driven with a bypass to the fresh-water service pump giving a dual system.

Oil Filters or Centrifugal Purifiers. Various methods of oil purification or filtration have been employed. As in the case of other engine-room auxiliaries a standard method seems imminent, and is resolving itself into the use of centrifuges. Other methods are wasteful and dirty. The centrifuge removes impurities leaving them in a semi-hard or plastic condition within the bowl. The filter or multiple strainer leaves the impurities in a heavy liquid state. The importance of a suitable method of reclaiming used lubricants is at once apparent when we realize that from 300 to 2000 gallons of lubricating oil may be in circulation and there is always the possibility of an inadvertent contamination with water, which would render the oil useless unless it could be reclaimed. Naturally other contaminating elements such as carbon, rust, and mill scale from the tanks, will need to be removed from the oil from time to time.

Machine Shop. Generally well equipped with lathe, drill press, grinding wheels, and work bench. Sometimes a blacksmith outfit as well.

The foregoing list is the common arrangement where the ship is electrically equipped throughout. Several modifications may be made to suit different opinions. The ship may be heated electrically and the small boiler done away with. If the auxiliary oil-engine generating sets use the air-injection principle of fuel atomization, oversize compressors may be substituted for the regular attached compressors and the surplus of air thus obtained would eliminate the need of the auxiliary compressor. Where steam winches are used a donkey boiler with condenser, air pump, feedwater pumps, and the regular oil-firing equipment would be added. In this event the generating sets might be made smaller, and the auxiliary compressor steam driven, since it is only used while maneuvering in or out of port. An alternative arrangement which is losing popularity is to have all of the auxiliaries enumerated driven with steam. This involves a sizable steam plant, materially increases the sea fuel consumption, and keeps the engine room uncomfortably hot in the tropics, but makes it comfortable in cold climates. This arrangement never has effected a saving in cost equal to the saving in fuel when electrical equipment was used throughout. It was formerly employed for the sake of dependability, a need which no longer exists.

The fact that certain types of pumps have been almost universally accepted is worthy of some explanation, for this standard was not reached without cause.

If steam is used the type of pumps will not be the same as given in the list. Naturally there is no need to make a departure, except in capacity, from standard steamship practice in such instances. What follows is with regard to electrically driven pumps.

The centrifugal pump is used for main circulating water be-

[1] By A. B. Newell. Part I appeared in the July issue, p. 715.

[2] Engineer in Charge Diesel Department, N. Y. Shipbuilding Corp. Mem. A.S.M.E.

[3] Guarantee Engineer, N. Y. Shipbuilding Corp.

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cause there is never any question of the supply of water, it requires practically no attention, repairs are inexpensive and the speed easily conforms to an efficient and economical speed of electrical machines. The head against which it pumps is relatively small.

For piston cooling the plunger pump is used with fresh-water circulation (if salt water is used the main circulating pump takes care of that as well) primarily to insure dependable service. Fresh water must be carried in tanks and the ship in rolling will uncover the suction pipe if the tank is partly empty. With air in the centrifugal pump it ceases to pump, but the plunger pump works along. The same thing applies to bilge, ballast, and fresh-water pumping.

Oils are handled well with rotary pumps for two reasons: they do not lose their priming easily, and the oil keeps them well lubricated. They have lost favor for bilge pumping because water is a poor lubricant at best and the bilge strainers do not remove small particles of grit such as rust and mill scale which are ever present in bilges. These fine abrasives keep cutting the wearing surfaces and repairs assume a place of importance. They may be used as ballast pumps but tend to give the same trouble, on a smaller scale, since certain abrasive sediment accumulates in these tanks also.

Common practice is to have an auxiliary compressor of the three-stage type similar to the main compressor. An alternative arrangement is to have a two-stage machine and an independent booster. With this latter the two-stage compressor pumps direct to the maneuvering tanks, raising the pressure to 350 lb. per sq. in. or less. The booster takes that air and lifts it to 1000 lb. or less.

The problem of auxiliaries for twin-screw installations does not differ greatly from that of the single-screw job. The proportionate amount of air storage is somewhat less in so far as maneuvering air is concerned, for a smaller engine will start with less air than a large one, and the tendency in maneuvering is to use one engine about half of the time. However, a complete dual high-pressure air system is required for each engine, which tends to balance the reduced amount of maneuvering air, as far as cost of installation is concerned.

A machine shop has been mentioned. This is more essential on the motorship than on the steamship. The routine work on a motorship requires about the same amount of labor as such work on a steamship. However, boiler work is eliminated—and this all applies to the engine room, particularly the main propelling units. The ship's engineers do this work because adequate means of having it done ashore have not been provided in all ports. Machine-shop work generally takes the form of facing valves and making small parts which may be broken or damaged during repair work. Not only at sea but in port the small shop pays for itself, for many of the small parts can be turned out aboard ship quicker than a messenger can go to the shop ashore and get them, if they have to be made in any event.

The trend is to reduce the number of auxiliaries with a view to reducing the cost but nothing of quality may be sacrificed for the same purpose, for the main propelling unit is just as dependable as the auxiliaries and no more.

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Discussion

In the discussion which followed the presentation of the paper, W. Mulheron[4] wrote that electrically driven auxiliary machinery always operated at maximum efficiency, provided the units had been properly selected for the service. The efficiency of electrically driven machines, he said, was practically constant. The efficiency of Diesel-engine-driven generators, as the source of auxiliary power, was also practically constant, he pointed out.

Although the electrical auxiliary machinery was inherently more expensive than the equivalent steam machinery, he said, the higher initial cost would be written off completely in a relatively short time, because of the remarkable economies obtainable. Direct current being almost universally used on shipboard, and owing to the fact that electrical equipment had been so standardized as to make repairs and replacements a relatively simple matter, a high degree of special knowledge was not required by the average seagoing engineer.

Experience had demonstrated that the principal requirements to be met for marine service were:

1 Insulation designed to withstand moisture and oil vapors
2 All fittings of non-corrodible material or with non-corrodible surfaces
3 Self-oiling bearings not affected by rolling or pitching; 150 deg. tilt being accepted as satisfactory.

Although the development of electrical equipment for cargo winches has been particularly difficult, he said that the development of the electric cargo-winch control had reached the point where it was superior to the steam winch.

He could not agree with the author's statement that steam winches were more flexible and easier to repair than electric winches, since the latter was of simpler construction. Experience of companies operating both types indicated more repairs and maintenance on steam winches than electric. Since a ship earned money only when she was at sea, the whole development in electric cargo-winch design had been to surpass the steam winch in speed of handling cargo, and to make it a far more reliable and economical piece of machinery.

Referring to the author's statement regarding voltage, he pointed out the fact that the Marine Rules of the A.I.E.E., specified a voltage of 240 or 120 for generators and 115 or 230 for motors. A voltage of 230 was generally used for power purposes and 115 volts for lighting, the latter being obtained by a motor-generator set or a balancer set.

Three-wire generator installations were not generally favored, because of the wide fluctuations in unbalanced load.

A higher voltage was not favored for lighting systems because of the greater durability of low-voltage lamps, and furthermore greater stocks of 110–120-volt lamps were available for replenishment. Difficulties with the lighting system, due to grounds, etc., were greater with 230 volts than with 115 volts.

Mr. Mulheron also pointed out that it was becom'ng the generally accepted practice to fit generators and large motors of the open type, a sheet-metal cover sometimes being provided. Small engine-room motors were generally of the semi-enclosed or enclosed ventilated types, the openings being generally fitted with screens to prevent the entrance of rodents.

The design of winch shown in Fig. 1 would involve very great difficulties, owing to conditions demanding the use of friction clutches, which had never proved satisfactory. Friction-drive winches had been popular with some of the coastwise steamship lines, but they were almost invariably located between decks, and, even so, their maintenance had been high.

A somewhat similar scheme, using a constant-speed, alternating-current motor connected by gears and clutches to two winches, was not successful.

Mr. Mulheron mentioned the great advantages of electric over steam deck machinery in winter, referring to the dangers of the freezing and bursting of pipes and cylinders and the necessity of maintaining steam pressure on the pipes in severe weather, also the practice of keeping the winches turning over slowly to avoid freezing, involving great steam losses.

In discussing the author's statement regarding loads handled by cargo winches, he said that either a change-speed gearing, or a shift in the boom rigging from a single whip to a multiple-part fall, or a combination of both, was provided for handling heavy loads.

The variations in course direction were of far greater importance than the mere steam or current consumption of the steering engine,

[4] Engineer, Marine Dept., General Electric Co., Schenectady, N. Y. Assoc-Mem. A.S.M.E.

for it had long been realized that speed was directly affected by the amount of helm necessary to keep the vessel on a straight course. Recent investigations at the United States Experimental Model Basin indicated that it was feasible to reduce the installed shaft horsepower of a given vessel and still maintain the average sea speed desired, when automatic steering was used.

Mr. Mulheron pointed out that the author had neglected to mention that with the Diesel-electric form of propulsion the necessity for maneuvering was entirely eliminated. The air-compressor capacity was only required to be that actually necessary for the operation of the engines, there always being sufficient excess in the bow-pressure stage to maintain the small starting-air tanks at the required pressure. He also called attention to the necessity for compressors with two-cycle engines for scavenging purposes, adding that Dr. Sanford A. Moss had covered the subject so thoroughly in his paper[5] that he need not comment further.

James A. Shepard,[6] in a written discussion of the paper took exception to the author's reasons for the continued use of steam-driven auxiliaries, his opinion being that habit, precedent, timidity concerning new problems, and an insensible leaning toward a low initial cost might also be prominent influencing factors, rather than actual merit.

The advent of entirely successful electrically driven deck machinery was comparatively recent, he said, hence it might be assumed that results so far observed did not cover all potential advantages. He felt that with natural ultimate progress in the art, much more favorable results might be expected.

The ability of electrically operated equipment to continue to operate with overloads of several hundred per cent Mr. Shepard considered a matter of the utmost importance. This inherent difference from steam-driven auxiliaries had been suitably reflected in the construction of electric cargo winches, hence frames, gears, bearings, etc. followed the precedents previously established for steam winches. A record of equal reliability, therefore, fell below the possibilities of the electric winch, which should develop a higher efficiency, and, unlike the steam winch, would fully retain it throughout its life.

Commenting on the author's assumption that the performance of the steam and electric winch were equal, Mr. Shepard said that that undoubtedly had been their relative status, but recent improvements in methods of control of the electric winch afforded still greater relative efficiency, while performance was raised from mere equality to a point far exceeding that obtainable with the steam winch.

Mentioning the fact that the average cost of loading and unloading cargo had been estimated at from 20 to 25 per cent of the direct disbursements for operating cargo ships, he said that the proportion of time spent in port might exceed 25 per cent; hence the efficiency with which cargo was loaded and discharged must bear a very intimate relation to total operating efficiency.

The mechanical efficiency of the cargo-handling equipment, while important, was but one of several factors which should be resolved into the one all-important consideration, net operating efficiency of the ship. In such a determination not only electric winches vs. alternatives should have consideration, but the right kind, the right number, the right arrangement of electric winches vs. alternatives must have consideration. Such a determination, he added, would rarely, if ever, leave room for doubt concerning the superiority of electric deck auxiliaries.

Mr. Shepard mentioned Mr. Newell's reference to the foregoing consideration indirectly in Part II of the paper, although he did not recognize the advantages which might be realized by shortening the time in port through the use of more and better equipment for loading and discharging cargo. Such an oversight, he said, was excusable, in view of the fact that we were only on the eve of developments which would, in any determination of overall efficiency, leave little, if any, room for argument as to the superiority of electrically operated auxiliaries.

Spencer Miller[7] contributed a written discussion in which he agreed with the author's statement that when working cargo the electric winches did the same work as steam winches, with a saving of approximately 90 per cent of the fuel. Commenting on the ship *Ashbee*, which burned in port as a steamer 7.6 tons of fuel, and after conversion to a motorship, 1.43 tons, he called attention to the fact that the steam winches had been retained, yet with them the saving in fuel was one-fifth. These particular winches, he said, were built for the wooden-ship program during the war, were $8^1/_4$ by 8 in., and were designed not for fuel economy but for simplicity, flexibility, and versatility, having been built to be handled by any class of labor. The control was a single lever, which was raised to raise the load, and lowered to lower it. Except in the one point of fuel economy they were the equal of any electric winch ever built, he said.

Referring to another case in which the fuel consumption of the electric auxiliaries amounted to but one-third of that of the steam-driven auxiliaries, Mr. Miller said that the cost of fuel was the smallest item in the comparison, adding that the efficiency of the winch was reflected in the size of motors and generators on which freight must be paid all the time. The cost of handling miscellaneous cargo in the port of New York averaged around $1 per ton. The fuel cost of the steam winch would be about three cents per ton, while that of the electric winch would be about one cent. Continuing, he said that from the standpoint of fuel cost the electric winch would not have a very great influence on the cost of handling cargo. However, the efficiency of the electric winch would be around 94 per cent in the mechanical parts, irrespective of the motor. No steam winch ever built, he argued, had a mechanical efficiency of 50 per cent, but the overall efficiency of one electric winch would be in the neighborhood of 85 per cent, which meant a tremendous saving in the weight of fuel and equipment, and was the real reason for the displacement of the steam winch.

L. M. Goldsmith[8] wrote that on the Diesel-electric-driven tanker *J. W. Van Dyke*, a vessel of 2200 shaft hp., only $2^1/_2$ per cent of the total brake horsepower developed, and therefore only $2^1/_2$ per cent of the fuel, was required for auxiliaries, whereas, quoting from the authors' paper, on a vessel of the same brake horsepower, with steam auxiliaries, approximately 22 per cent of the fuel was required for the auxiliaries and, with electrically driven auxiliaries, approximately 3 per cent; taking all of the foregoing as overall or average figures.

Assuming the power taken by the compressor as 10 per cent to 15 per cent of the total power of the main engine, this amount should be added to the power taken by other auxiliaries, he explained, which, in the ships mentioned, would bring the total percentage of power taken by auxiliaries to from 12 to 18 per cent. It therefore appeared that on the *J. W. Van Dyke* an extra $9^1/_2$ per cent to $15^1/_2$ per cent of the total power was available for propulsion. In connection with these figures, he added, it should be noted that the *J. W. Van Dyke* engines were of the mechanical, or solid-injection type, and therefore in comparing them with the air-injection type the injection compressor should rightly be considered as an auxiliary. Aside from the above, the electrically propelled vessel required no extra air for maneuvering, he said, as it was maneuvered electrically, and therefore, when operating in restricted waters, had no greater auxiliary load than when operating at sea.

In addition, Mr. Goldsmith explained, such a vessel had no auxiliary generator sets, as the main Diesel-electric generating sets also supplied the auxiliaries, resulting in a reduction of the capital cost. The ship being equipped with solid-injection engines, it had no high-pressure air compressors for injection, and therefore required air only for starting.

Applying the author's formula for auxiliary air-compressor capacity in cu. ft. of free air per min. to the *J. W. Van Dyke*, he showed that

$$W_c = \frac{WP}{150} \text{ instead of } \frac{WP}{90}$$

This formula, changed as above, would, he believed, apply to the capacity of the starting-air compressor for starting Diesel-electric

[5] See Mechanical Engineering, vol. 47, p. 1075.

[6] Vice-Pres., Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. Mem. A.S.M.E.

[7] Chief Engineer, Lidgerwood Mfg. Co., New York, N. Y. Mem. A.S.M.E.

[8] Technical Assistant to President, Atlantic Refining Co., Philadelphia, Pa. Mem. A.S.M.E.

units, it being necessary to overcome only the engine friction and the generator and exciter windage.

He mentioned claims made that the power consumption of the direct-connected steering gear was not as great as that of a hydro-electric steering gear, and said that while he had no figures to refute those claims, the actual power required in the former case was greatly in excess of that required in the latter, and it was therefore necessary to take care of this demand in available auxiliary generator capacity for the momentary load. This of course increased the cost of the Diesel-electric auxiliary generating unit, and the decreased cost of the direct-connected steering gear was thereby offset by the greater capitalization in the stand-by capacity required.

Harte Cooke[9] wrote that it had been his experience that electrically driven auxiliaries gave less trouble and required less maintenance than steam-driven auxiliaries.

The capacity of the air compressor reduced almost directly as the reduction in speed, he pointed out, while at slower speeds, the volumetric efficiency would increase somewhat, and this increase would by no means make up for the reduction in capacity, due to the lower number of revolutions.

The consumption of air increased as the speed reduced. While the fuel valves opened a few number of times, they remained open longer, so that the total time they were open was about constant. Also, at the slower speeds, there was less fuel being used, which gave a chance for still more air to pass through the fuel valves, the practical effect of this was shown in Fig. 2. With a reduced delivery of air and a constant time of opening for the fuel valves, the injection pressure would naturally decrease.

The above, Mr. Cooke maintained, showed that the larger the capacity of the compressor, the higher the injection pressure that could be maintained at slow speeds, and with certain fuels the compressor capacity would undoubtedly limit the minimum speed at which the engine could be operated. A marine compressor provided with proper unloading devices permitted the normal demands to always be met with good mechanical efficiency, and any excessive reduction in the capacity of the compressor to reduce the weight and cost would tend to limit the ability of the engine to perform at the slower speeds.

Martin L. Katzenstein,[10] commenting in writing, referred to the question of moderate-speed vs. high-speed auxiliary generating sets. He felt that simplicity of construction should be the deciding factor, for with it, with an engine properly designed, low maintenance costs were to be expected. For the cargo vessels discussed in the paper he pointed out that the size of auxiliary units never exceeded 100 b.hp., and speeds below 350 r.p.m. would result in designs excessively heavy, bulky, and correspondingly high in cost.

Oversize air compressors for supplying maneuvering air for the propelling engine, he said, involved the continuous operation of large low-pressure pistons, resulting in a continuous waste of power. A simple (though not compact), economical, and reliable combination for auxiliary engines, generators and maneuvering air compressors described by Mr. Katzenstein consisted of (*a*) a solid-injection engine running at a speed of from 300 to 375 r.p.m., in powers ranging from 60 to 120 hp., direct connected to (*b*) a generator, and driving through a magnetic clutch fitted to the extended generator shaft (*c*) of a maneuvering air compressor. The magnetic clutch, controlled from the propelling-engine operating platform, permitted operation of the compressor as needed, eliminating a separate prime mover for the maneuvering compressor.

Magnetic clutches, Mr. Katzenstein said, were entirely reliable in service, and such combinations as described could be seen on a number of American-built or converted motorships.

He further pointed out that if the auxiliary engines were of a port-scavenging, two-cycle design, provision could be made for burning the fuel used in the propelling engines. Such designs were simple and required a minimum of attention from the operator.

The fixed charges against the excess cost of Diesel machinery for ships, he said, had been one of the real causes for retarding the development of the motorship in this country. It had been stated that the disadvantage of high cost diminished in proportion to the time that the machinery was kept at work. This had two applications, he said, i.e., in long voyages (with quick turn-around) and utilizing the running gear of the propelling engines as great a part of the time as possible. Foreign competitors were better placed than Americans for long voyages, and this would account for the greater progress in motorship development abroad. He mentioned efforts made to overcome this in the development of the double-acting, two-cycle oil engine, citing a paper[11] on the subject presented before the Society in December, 1924, by Dr. C. E. Lucke.

So far as producing power was concerned, he said, the double-acting two-cycle engine functioned like a reciprocating steam engine. This type of engine, by utilizing the running gear for every stroke, produced power at a lower cost than was possible with single-acting engines; and in this direction he felt that the march of progress was heading.

Joseph Hecking,[12] commenting on the necessity of the larger number of auxiliaries required for Diesel ships than for steamships, wrote that this was due to the extreme caution of engine builders and classification societies in not taking chances on the complete success of the marine Diesel engine in its infancy. The effect of their caution, he said, was seen in the rapidly increasing number of Diesel-engined ships.

In a general comparison of auxiliaries for steam and Diesel plants he pointed out that we must not forget to include in the steam plant all accessories and the comparatively large and expensive piping systems. If it were true that the Diesel plant had a larger number of auxiliaries than a steam plant, it would not be possible to operate the former with a considerably smaller engineers' crew than required for a steam plant. He was convinced that the excess in cost of the Diesel-engine installation was entirely due to the greater cost of the main Diesel engine. In speaking of Diesel engines, one had in mind the fully developed four- and two-cycle single-acting air-injection engines, and while the solid-injection engine had been fully developed in small and medium sizes, the upper limit in their development had not yet been reached; nor were engineers aware of the limits of the double-acting two-cycle engine. Both developments, if carried out successfully, should effect a reduction in the first cost of the Diesel plant.

Commenting on the authors' statement that usually not less than three Diesel generator sets were fitted, Mr. Hecking said that they probably meant "not more" than three sets. In vessels of short coastwise routes, with a fixed sailing schedule and little time in port, it might be desirable to carry a spare generator set, but for long-distance routes it looked like a waste of money and tonnage, and the total kilowatts need not be greater than the maximum port load. It required not more than six installations to demonstrate the folly of placing steam auxiliaries on Diesel ships, he said, and even the suggestion would appear like a backward step.

Mr. Hecking felt that the authors were partly justified in their remarks relative to handicaps by classification societies, but added that the rules of the American Bureau of Shipping were developed with the advice and coöperation of all important engine builders in this country, and the various restrictions had prevented enthusiastic engineers from spoiling the success of the marine Diesel engine. Furthermore, salt-water jacket cooling, fresh-water or oil piston cooling, and pressure lubrication were not requirements of the classification society, but entirely a builder's choice. The values given by Güldner, namely, the ratio of cylinder volumes to low-pressure-compressor volume, equal to 10 for two-cycle engines and 20 for four-cycle engines, seemed to apply very satisfactorily. He mentioned the fact that the engineers of the United States Shipping Board had incorporated a requirement covering fuel-valve lift control on marine engines in their specifications for Shipping Board engines. He added that the effect on the size of the attached main compressor was readily understood when it was considered that the quantity of air flowing through a fixed orifice was dependent on the period of valve opening.

With regard to the reference to the American Bureau rules for compressor capacities, he stated that endeavors had been made to make the requirements adequate and clear, but conditions might arise where the definitely stated requirements did not apply, and such cases would be considered on their merits. The underlying principle of all classification rules was the safety of ship and cargo.

[9] McIntosh & Seymour Corporation, Auburn, N. Y. Mem. A.S.M.E.

[10] Manager, Marine Department, Worthington Pump & Machinery Corporation, New York, N. Y. Mem. A.S.M.E.

[11] Trans. A.S.M.E., vol. 46, p. 1005.

[12] Surveyor of the American Bureau of Shipping, New York, N. Y.

Harold Anderson[13] wrote that one reason for the usual prejudice against waste-heat boilers was probably the prevailing opinion that, inasmuch as the exhaust temperature from a Diesel engine was practically the same as the temperature of the flue gases from a boiler, there was no justification for the installation of a boiler. The fact that in land practice economizers were used in connection with boilers, bringing the flue gases down to from 200 to 300 deg. fahr., was apparently lost sight of, he said.

Commenting on the application of waste-heat boilers to make use of steam-driven auxiliaries, he felt that the better application would be to use the steam so generated in a steam-driven generating set, which in turn would supply the electrically driven auxiliaries. Such an installation would make it possible to have the auxiliary machinery all electric, he said, thus simplifying the engine-room arrangement and effecting a saving of fuel of possibly 5 per cent. He recommended Diesel-driven auxiliary generators as spares and for port use.

Electric heating was very convenient for remote places and attractive in passenger service, Mr. Anderson pointed out, but it should be kept in mind that it was expensive. Assuming that the auxiliary-electric-generator engine required 0.5 lb. of oil per b.hp-hr. or, say, 0.75 lb. per kw-hr., it was obvious that the use of one pound of fuel would only give $3412/0.75 = 4550$ B.t.u. at the point of use. He quoted figures showing that steam heating was apparently the most economical solution.

William H. Thompson[14] wrote that if there was any demand for heat, a boiler should be considered. If not, and the engine was of large power, then consideration should be given to steam generation by exhaust gases. If heat only was required, he said, it must be borne in mind that every 600 B.t.u. saved from the exhaust gases would mean an expenditure of from 900 to 1000 B.t.u. if oil were to be burned under a boiler.

Although the method of arriving at the approximate saving in B.t.u. had been outlined by the author, he said, the final figures should be arrived at in consultation with the manufacturer of the boiler, the design of which latter was important, the maximum of efficiency being obtained through the proper ratio of area of exhaust gas passages to length of travel.

The fire-tube type could be figured most accurately, he felt, and it also permitted of more thorough cleaning of soot deposits.

In answer to the often-asked question whether the exhaust gases from Diesel engines would corrode the tubing, he said that a generator examined after nearly two years of service did not show any effect of gases on the tubing after it had been cleaned.

He claimed that these boilers could be so proportioned that they would add no appreciable resistance to the discharge of exhaust gases; in fact, they tended to decrease the back pressure on the engine. It had also been found that the exhaust gases from two engines could be discharged into one generator, with success.

It had not been found practicable to have the exhaust gases and an oil burner working in the same boiler at the same time; since exhaust gases being at a temperature considerably lower than the flame of the burner, the mixture of the two gases would have an average temperature much lower than the flame temperature, and considerably more heating surface to absorb the heat would be required.

If it were necessary to develop more steam than could be obtained from the exhaust gases, the more practical and efficient method would be to have two separate boilers. If steam was required practically all the time, and a sufficient amount could be obtained from the exhaust gases when the engine was in operation, then the boiler should be equipped with a suitable firebox so that the oil could be burned under it when the engines were not in service.

A. W. Robinson,[15] in a written discussion, said that one of the most promising fields for Diesel-electric power was that of dredging machinery, since in this class of machinery almost the whole power was consumed by auxiliaries. He favored electrical distribution of power. In his search for a suitable oil-electric engine to do this kind of work, he said he had been forced to choose between a large, slow-moving engine, adapted for screw propulsion, and a very small type of high-speed engine of the racing-machine or aircraft type, neither of which was suitable for the purpose.

He urged the production of something between the ponderous, slow-moving marine type and the fast-running aircraft type, of a kind that would be suitable for electric generation of power and easy for the average marine engineer to learn to operate. He mentioned an engine brought out in Europe which was of the high-speed type, running at about 600 r.p.m. and weighing about 10 lb. per hp.

Shaft Rubbing

Relative Freedom of Rotor Shafts from Sensitiveness to Rubbing Contact When Running Above Their Critical Speeds

By BURT L. NEWKIRK,[1] SCHENECTADY, N. Y.

In the *Zeitschrift des Vereines deutscher Ingenieure* for July 25, 1925, on page 985, Dr. D. Thoma describes a case of vibration of a vertical rotor having four journal bearings and one thrust bearing. This was the rotor of a water-wheel generator running at 600 r.p.m. and having critical speeds well above the running speed. The unit ran well for a few weeks and then developed in the space of a few minutes severe vibration in its lower section, necessitating a shutdown. This occurrence was repeated after a considerable period of quiet operation. A second machine in the same station developed the same trouble.

Observations made immediately after one of these fits of vibration indicated that the shaft was bowed in its lowest section and that the bow disappeared within a few minutes after shutdown. It had been observed previously that the bearing at the upper extremity of the lowest shaft section (the bowed section) ran warmer than the others.

Bowing of Shaft Resulting from Rubbing

Dr. Thoma explains the deformation of the shaft on the theory that it is in unstable equilibrium as regards heating in the bearings. That is, if the journal becomes heated along one element of its surface, the shaft bows so that this element is pressed against the bearing and becomes still hotter, which results in further bowing, etc. Thus, when a cycle of this sort starts it progresses rapidly, and violent vibration develops.

This theory is in accord with common experience with rotors of stiff-shaft design. It is well known that a rotor running below its critical speed is sensitive to rubbing contact with the shaft at any point between the outer bearings. This sensitiveness is due to the cycle just described, complicated by the unbalance, which changes as the shaft distorts. When a rotor runs below its critical speed the heavy side runs out, and it is in general this side which touches whenever rubbing starts. Whether rubbing begins on the heavy side or not, the heat developed bows the shaft so that the rubbed side quickly becomes the heavy side. The heat developed by the rubbing then continues to expand the metal of the shaft on the heavy side, bowing out the shaft and causing greater unbalance and heavier rubbing, which in turn develops more heat, and so on in a vicious cycle. The shaft tends to dig into any surface brought up to it.

It is perhaps not so well known that shafts running well above

[13] General Engineering Division, Westinghouse Electric & Mfg. Co., South Philadelphia Works, Philadelphia, Pa. Assoc-Mem. A.S.M.E.

[14] Chief Engineer, Davis Engineering Corp., New York, N. Y.

[15] Consulting Engineer, Upper Melbourne, Province of Quebec, Canada. Mem. A.S.M.E.

[1] Research Laboratory, General Electric Company.

their critical speeds are not subject to this form of instability. At such speeds the shaft bows so that the heavy side is concave, and any light rubbing that occurs heats the light side (the outside) and causes the shaft to withdraw itself from the surface against which it rubs. An exception to this statement must be made of the case of shafts running true and in perfect balance, and of shafts having a ridge or prominence which rubs first, irrespective of the state of balance. These cases will be taken up later.

Cases Considered

To visualize the effects described above, assume a rotor supported at two bearings, consisting of a shaft of negligible weight carrying a heavy disk eccentrically mounted.

Case I, Fig. 1, shows a rotor running below the critical speed and Case II shows it running above critical speed. In both cases equilibrium exists between the centrifugal force due to the whirling mass and the elastic restoring force of the shaft. In both cases the rubbing heats and expands the elements on the outside of the shaft, weakening its elastic restoring force. In Case I equilibrium can be reëstablished by increasing the radius of whirl, but in Case II it can be reëstablished by reducing the radius of whirl. This can be verified by setting up the algebraic condition of equilibrium for each case. It should be directly evident, however, that in Case I where the center of mass is outside the shaft the ratio of elastic restoring force to centrifugal force increases with increasing radius of whirl, and in Case II this ratio increases with decreasing radius of whirl.

In Case I, if the solid body is brought up to the whirling shaft so as to produce light rubbing, the shaft should bend more and try to dig into the surface, getting progressively rougher. In Case II,

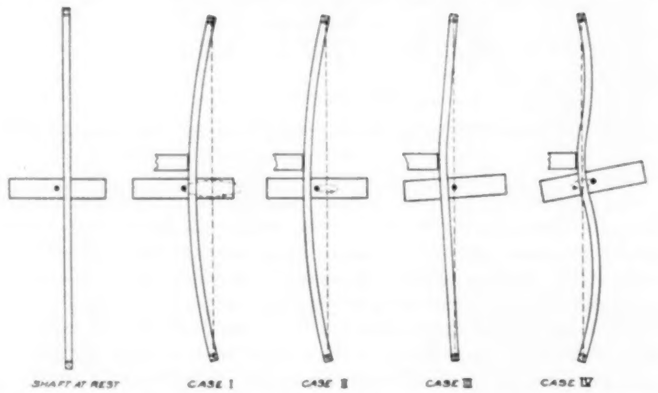


Fig. 1 Shaft of Negligible Weight Supported at Two Bearings and Carrying a Heavy Disk Eccentrically Mounted

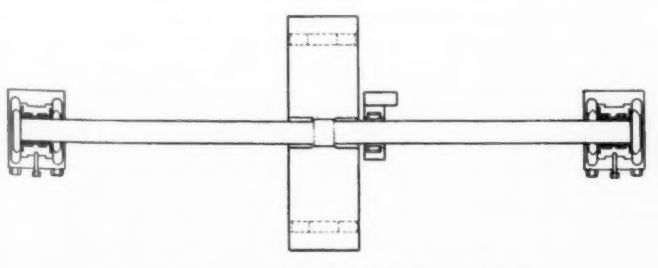


Fig. 2 Model for Shaft-Rubbing Tests

if the solid body is brought up so as to be rubbed by the whirling shaft, the radius of whirl should decrease, and the shaft should withdraw itself from the solid body. The rotor would then run in better balance than before.

If now in Case II the solid body be brought nearer still, the shaft should again withdraw itself, and this cycle should continue until the shaft runs in balance with its center of gravity on the line of bearing centers (Case III). The shaft would, however, still be whirling owing to the eccentric mounting of the disk. The bend in the shaft shown in the figure is due to the heating up of one side of the shaft, which is under no bending stress.

If now the solid body still moves toward the shaft, the rotor would continue to withdraw until finally the shaft ran true at the rubbing surface, but out of balance by reason of the eccentric mounting of the disk (Case IV).

Since the shaft has now come to run true at the rubbing surface it can no longer withdraw from the surface, but if rubbing continues the shaft would not tend to dig in with one element getting more and more heated. Any further heating of this one element would increase the distortion of the shaft shown in Case IV and so cause the element on the opposite side of the shaft to rub. Thus the rubbing would pass rapidly from one element of the shaft to another and there would be no further progressive bending of the shaft.

The shaft running true and in perfect balance would also behave in this way. It could not withdraw from a rubbing surface, but

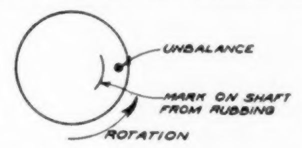


Fig. 3 Sketch Showing Location of Rubbing on Shaft with Respect to the Unbalance

different elements of the shaft would receive the rubbing successively so that no considerable bowing would occur in any given direction. In all of these cases except Case I it is assumed of course that the shaft is running well above its critical speed.

Experimental Study of Phenomenon

This phenomenon was studied experimentally in the course of

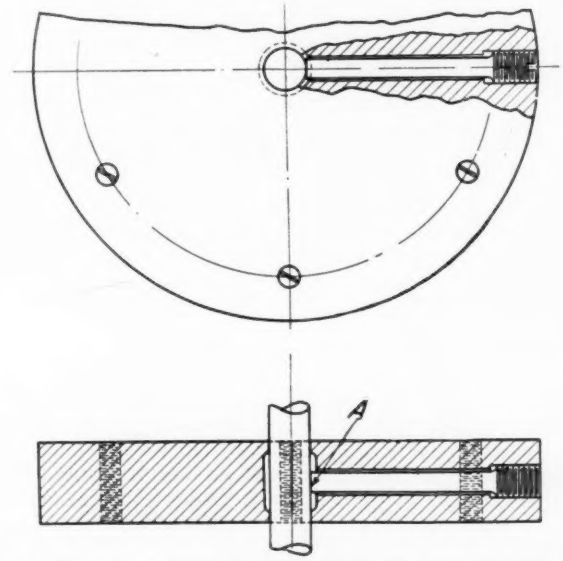


Fig. 4 Method of Mounting Disk to Produce Unbalance by Bowing Shaft

a study of shaft behavior made in the General Electric Company's research laboratory some time ago. A rotor shown in Fig. 2 was first balanced carefully, and then an additional balance weight was inserted to throw the rotor out of balance by a known amount at a known point. The rotor was then run at various speeds and a surface was set so the shaft rubbed slightly against it. When the rotor ran below its critical speed the result was in all cases that rubbing increased in intensity, building up more rapidly the more severe the rubbing. When the shaft was examined after the run the mark due to rubbing was found on the heavy side (Fig. 3). When the speed was above the critical speed of the rotor the rubbing, if not too severe at the start, did not build up but cleared itself without removal of the rubbing surface. If the rubbing was too severe with the shaft running above its critical speed, the frictional resistance to rotation would reduce the speed below the critical, and vibration would then build up.

To supplement this test the unbalance was produced in a different way, which, however, should make no difference in the behavior of the rotor. Fig. 4 shows a disk mounted so that pressure can be exerted on the shaft at A, causing the shaft to bow. The rotor was first nicely balanced with the shaft running true. An

unbalance was then introduced by bowing the shaft and holding it in this condition by the radial bolt instead of inserting an additional balance weight. The unbalance was introduced in this way because it seemed hard to believe that a bowed shaft carrying balanced disks would bend in the reverse direction when running above its critical speed (Fig. 5).

This rotor was not used for rubbing tests, because its shaft was of small diameter and it seemed likely that the heat due to rubbing would distribute itself rapidly and have little bowing effect. However, the shaft was marked to determine the high side when running at speeds below and above the critical. These marks were on opposite sides of the shaft, and showed that when running above critical speed the shaft bends backward as shown in the second diagram of Fig. 5.[2]

These tests were made by Mr. H. D. Taylor who was working with the author at that time.

According to the theory, the high side of a rotor running above critical speed is not quite opposite the heavy side. However, it is more nearly opposite the heavy side the higher the speed, and for speeds 10 per cent above the critical speed it is nearly enough opposite the heavy side to permit the shaft to clear itself of rubbing as described above.

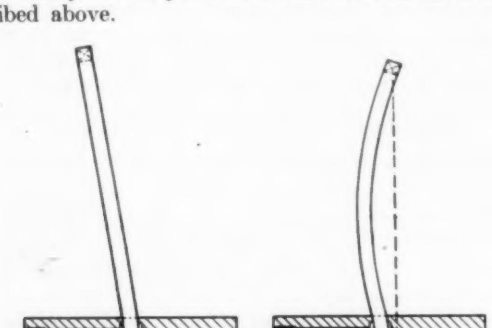


FIG. 5 DIAGRAMMATIC REPRESENTATION OF THE BACKWARD BENDING OF SHAFT RUNNING ABOVE CRITICAL SPEED

Returning now to consideration of the model shown in Fig. 2, Fig. 6 shows the rate at which the amplitude of vibration built up in one test with the model running below its critical speed. The critical-speed vibration of this rotor occurred between 1960 r.p.m. and 2275 r.p.m., and the running speed during this test was 1800 r.p.m. Before rubbing started the amplitude of vibration of the shaft was 10 mils (total motion). When a brass surface was brought up to touch the shaft gently, the amplitude built up at first slowly and then more rapidly, so that it doubled in four minutes. At speeds of from 2200 to 2240 r.p.m., only slightly above the critical, repeated rubbing failed to cause any increases in the amplitude of vibration, and if the rubbing was not too severe the shaft would clear itself.

It is of course not to be assumed that rubbing contact will in all cases start along that element of the shaft which should run out, according to the simple theory of shaft behavior outlined above. The shaft might be out of round, or bowed and balanced in such a manner that some other element becomes heated when rubbing begins. In any case, however, light rubbing will almost certainly heat the shaft unevenly, and that element of the shaft which gets the most heat will tend to expand and so to bow the shaft. This will change the unbalance of the rotor in the manner of the experiment made, in which a radial bolt was used to bow the shaft (Fig. 5). The effect of rubbing, then, is to tend toward making the rubbed side the heavy side, and consequently to bring on the vicious cycle described above if the rotor runs below its critical speed, and to relieve the rubbing or at least not to build it up if the rotor is running above its critical speed.

CASES WHERE RUBBING STARTS ON SIDE OF SHAFT OPPOSITE TO THAT INDICATED BY THEORY

Consider for example, two hypothetical cases, in both of which it will be assumed that the rubbing starts on the side of the shaft exactly opposite to that indicated by theory.

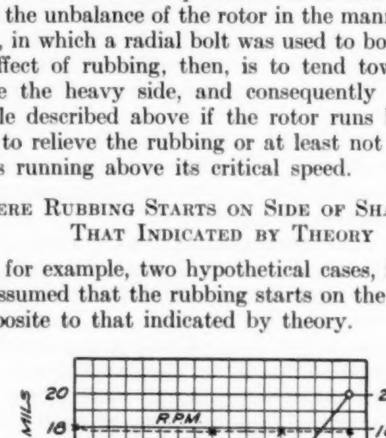


FIG. 6 RUBBING OF SIDE ON BRASS GUARD RING SET FOR ABOUT 5 MILS CLEARANCE

Suppose, first, that with a shaft running *below* its critical speed, the rubbing starts on the side of the shaft opposite to the location of the unbalance, due to a ridge or prominence of the shaft on that side. The *rubbing* should increase in violence, even though it improves the *balance* at first by bowing the shaft outward on the rubbed side. The bowing outward on the rubbed side increases the severity of the rubbing. Very little bowing of a shaft (say, five thousandths of an inch at the center) is sufficient to produce a predominent unbalance on the bowed side. The rotor would soon get badly unbalanced and the cycle should proceed as described above.

In the second case, suppose that a shaft running *above* its critical speed rubs on the side of the unbalance, due to some ridge or other prominence of the shaft on that side. The unbalance would increase on account of this rubbing, but owing to the fact that the heavy side runs in when a rotor runs above its critical speed, the shaft would simply bend backward as described above (illustrated in Fig. 5), so as to withdraw the prominent element from the rubbing surface. In this case, therefore, the vicious cycle would not occur.

It is by no means intended to give the impression that rotors running below their critical speeds cannot endure any rubbing whatever. The fact is that such rotors do frequently rub and clear themselves. They are, however, sensitive in this respect. The object of this note is to call attention to the relative freedom from such sensitiveness of rotors which are running above their critical speeds.

The cases of rotors having three or more bearings are too complex to admit of very satisfactory discussion from a theoretical point of view. However, experience seems to show that three-bearing rotors running below their lowest critical speeds are sensitive to rubbing contact with the shaft. On the other hand, it is a matter of experience with three-bearing sets running between their second and third critical speeds that rubbing the shaft sometimes causes rough running, but that such roughness does not build up to dangerous proportions.

[2] Another rather violent effect was found to follow when this model was subjected accidentally to *severe* rubbing. The rubbing surface was a wooden bushing in a metal guard ring surrounding the shaft with considerable clearance, and carried on a rigid standard. Upon several occasions when the rubbing became too severe the tangential force of friction caused the shaft to roll around on the inner surface of this wooden ring with great violence. The frictional resistance to rotation was so great that the model was brought to rest quickly. This phenomenon does not occur unless the shaft rubs very hard on a solid ring rigidly held.

The 1925 A.S.M.E. Student Prize Award Paper

A Study of the Effect of End Shape on the Towing Resistance of a Barge Model[1]

By HARRY PEASE COX, JR.,[2] EAST ORANGE, N. J.

The end shape of a scow has a very marked effect on the towing resistance, especially at speeds above 4 knots, and this is particularly true of loaded scows. The blunt type of end in extensive use on scows at the present time is a highly inefficient form. It has been found by the author that by using an end with a 22-deg. slope the tow-rope horsepower required in towing a scow can be practically cut in half. This means that the indicated horsepower of the engines in the tug would be more than cut in half, due to the fact that the slip of the propeller is greatly increased at the greater loads, and the propulsive coefficient of the tug is thereby considerably decreased. Particulars of the experiments which led to these conclusions are given in the subjoined thesis.

The object of the investigation about to be described was to determine whether or not the shape of the ends on a scow makes any appreciable difference in the power required in towing the scow. The tests were carried out on a scale model of the scows used by The Great Lakes Dredge and Dock Company, with several differently shaped ends and at various speeds, and formed an extension of certain experimental work done in 1911 by Prof. Grant K. Palsgrove of the Rensselaer Polytechnic Institute.

In what follows the "body" is considered to be that part of the scow, or model, which is always in the shape of an oblong box, regardless of the shape of the ends, and is the part indicated by *A* in Fig. 1. The term "freeboard" refers to the height of the deck of the scow or model above the surface of the surrounding water; and the "surface" of the model is to be taken as that portion of the exterior which is under water, and is therefore active in producing frictional resistance.

Scope of Tests

The tests were made on ends of five different shapes, and those chosen were such as might all be reasonably applied in the construction of a full-sized scow. The resistances of the model at five different speeds, which corresponded to speeds of from approximately four to eleven knots for the full-sized scow, were determined with the model fully loaded, and the resistances of the empty model were determined at four different speeds covering practically the same range. The resistances of the models were resolved into wave- and eddy-making resistance and skin friction, and were all related to a full-sized scow of a standard displacement of 2500 tons. The tow-rope horsepower required at various speeds was computed and plotted for the scow when both loaded and empty.

Apparatus

The model was made to a scale of $^1/_4$ in. = 1 ft. The body *A* was made from pattern pine and was 38.5 in. long, with an extension of the deck at either end as shown by *B*, *B* in Fig. 1. These extensions enabled the ends having the shape to be tested to be attached to the body. The model was $10^3/_4$ in. wide and had a groove $2^7/_8$ in. wide and $^7/_8$ in. deep extending the full length of the model along its center line.

The ends were also made of pattern pine and constructed in the shapes shown by *C*, *D*, *E*, *H*, and *L* in Fig. 1. Ends *C* are designated as "parabolic ends" and have a bottom curvature, lengthwise of the model, which is in the form of a parabola, while the transverse curvature is in the form of a circular arc of considerable diameter. Ends *D* are designated as "double circular ends" and have a bottom lengthwise curvature which is in the form of a quadrant of a circle, while the transverse shape is semicircular. Ends *E* are designated as "22-deg.-slope ends" and are constructed in the form of a plane surface perpendicular to the sides of the model and making an angle of 22 deg. with the horizontal. Ends *H* are designated as "35-deg.-slope ends" and are similar to ends *E*, except that the plane makes an angle of 35 deg. with the horizontal. Ends *L* are designated as "blunt ends" and consist of a front which is perpendicular to both the sides and bottom of the model, and at the bottom of this surface is joined to the bottom of the end by a circular arc. The ends are fastened to the model by means of two dowel pins in the body and three screws through the deck extension.

The experiments were performed in the flume of the Mechanical Engineering Laboratory of the Rensselaer Polytechnic Institute.

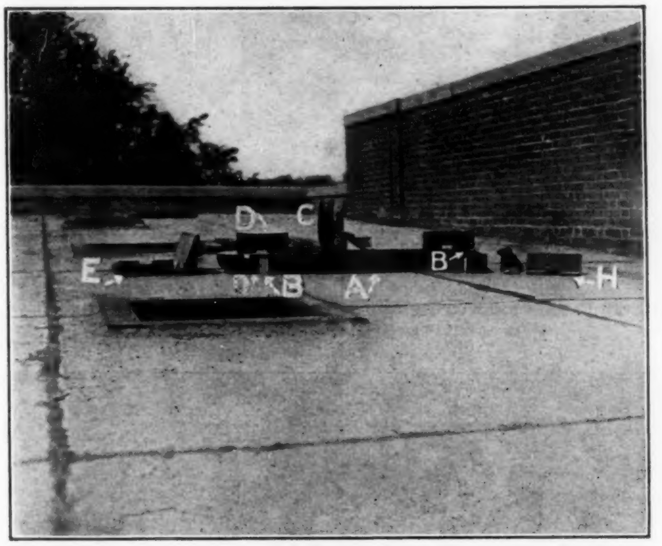


Fig. 1 Body of Model and Various Types of Ends

This flume is 90 ft. long, 45 in. wide, and 4 ft. deep. Along the top of the flume is placed a track (*T*–*T*, Figs. 2 and 4), on which runs a small hand car used to tow the model.

On this hand car, which is shown in Figs. 2, 3, and 4, is mounted a load arm which is similar to a bell-crank lever, and this arm is mounted on horizontal pivots *N*, Fig. 3, so that one arm *V* extends vertically down toward the surface of the water (Figs. 3 and 4) while the other, *H*, extends forward in a horizontal direction (Fig. 3). The model is fastened to the lug *L* (Fig. 4) on the vertical arm, while the weighing scales are operated from the horizontal arm.

A Fairbanks grocers' scale was especially fitted with an electric contact device *E* (Figs. 3 and 4) and a loop *M* (Fig. 4), to which the horizontal arm was attached through a knife edge *K* (Fig. 3) and wire *W* (Fig. 4).

An electric contact device was also located on the side of the car as shown at *D* (Fig. 4). This device made contacts with the small distance pegs *P* (Figs. 2 and 4) placed at 8-ft. intervals along the side of the flume.

A Gaertner chronograph (Fig. 5) was used in recording the data on each run. A sheet of tracing paper was placed on the drum *D*, which is driven by weights through a cord drum and gears shown at *M*. The governor *G* insures a uniform speed of revolution of the drum. Pen *C* indicates seconds as ticked off by the master clock, pen *S* when contact is made with space pegs, and pen *W* whether or not the scale arm is balanced. Switch *A* operates pen *C*, and switch *B* operates pens *S* and *W*. Separate switches are also located on the car at *X* and *Y*, Fig. 4. The trolley wires are shown by *R*,*R*, Figs. 4 and 5. The chronograph was stopped by pulling the string *F* (Figs. 2, 3, and 4), which operated the trip *W* (Fig. 5) and opened switch *A*.

[1] A graduating thesis submitted in June, 1925, to the faculty of the Rensselaer Polytechnic Institute, Troy, N. Y.

[2] Hevi Duty Electric Co., Milwaukee, Wis.

Theory of Calculations

The resistance of a model scow when towed through water has been considered as being divided into two main parts. The first part is due to the skin or surface friction of the body of the model and is independent of the shape of the ends of the model. The second part is that caused by the formation of waves and eddies and depends largely on the shape of the ends. The frictional resistance was determined by computation, and this was subtracted from the total resistance indicated by the tests in order to obtain the resistance due to wave and eddy formation.

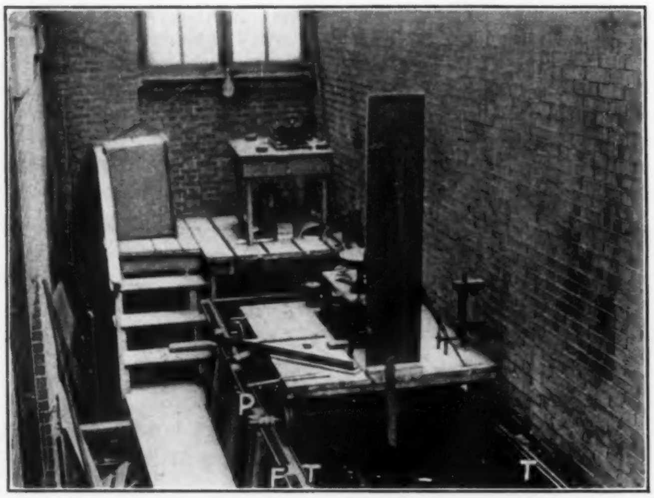


Fig. 2 Flume of the Rensselaer Mechanical Engineering Laboratory, with Apparatus Employed

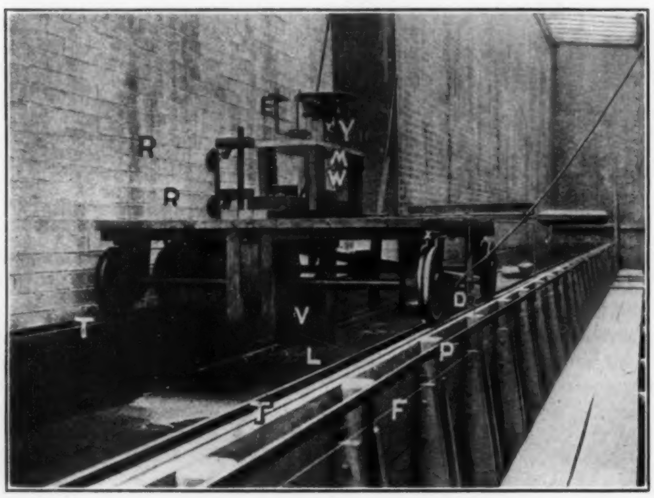


Fig. 4 Hand Car and Complete Set-Up of Apparatus

Attwood's formula[3] for the resistance of a varnished surface $38^1/_2$ in. long may be put into the form

$$R = 16fS\left(\frac{V}{10.13}\right)^{1.95}$$

where R = resistance in ounces
f = coefficient as obtained from table on page 318 of Attwood,[3] and depending on the nature and length of the surface
S = surface in square feet, and
V = speed in feet per second.

In determining the frictional resistance of the scow the formula given by Attwood (p. 321) was used, namely,

$$R = f'S\frac{W_0}{W}V^{1.825}$$

where W = density of salt water
W_0 = density of fresh water
R = resistance in pounds
f' = coefficient given by Attwood (p. 321)
S = wetted surface in square feet, and
V = speed in knots.

The term W_0/W was included because the coefficient f' is given for salt water and the results are desired for fresh water.

In applying the results of the model tests to the full-sized scow it is necessary to use Froude's law of comparison as given by Att-

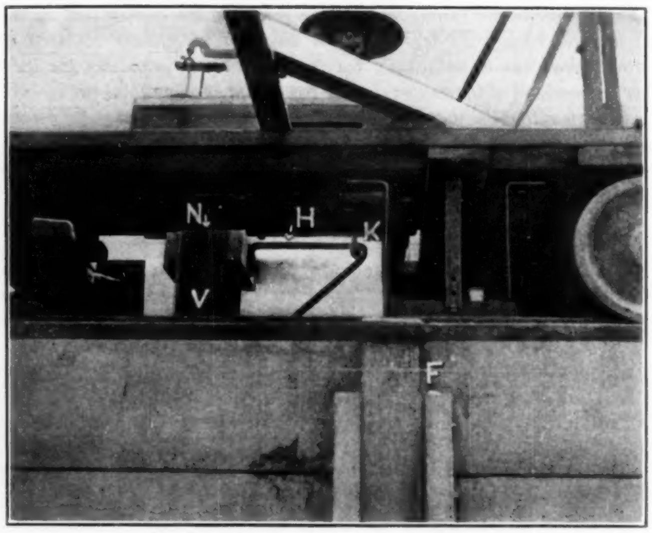


Fig. 3 Hand Car and Weighing Arms

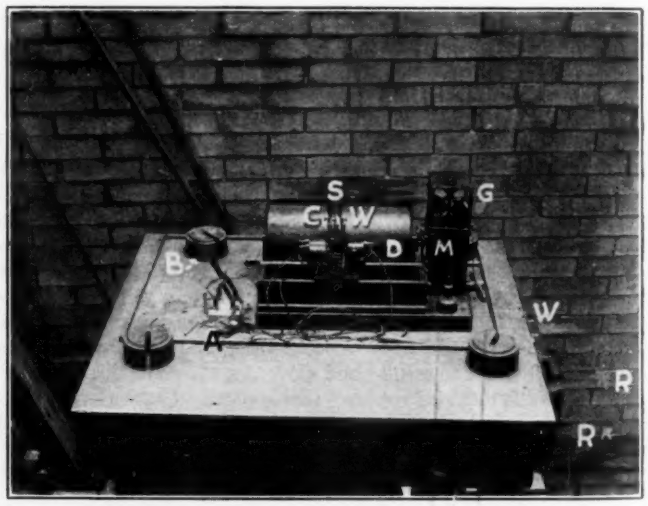


Fig. 5 Set-up of Chronograph

wood (p. 335), which states that the resistance of the scow is equal to the cube of the scale ratio times the resistance of the model. This is entirely true, however, only in the case of the eddy- and wave-formation resistance, and does not hold for frictional resistance on account of the decreased effect of friction due to the much greater length of the scow's surface. It is therefore necessary to compute the frictional resistance of the scow without regard to that of the model.

The corresponding speeds of the model and scow are determined also by Froude's law of comparison, which states that the corresponding speeds are proportional to the square root of the scale ratio.

Procedure in Testing

A few preliminary runs were made in order to determine the scale settings which would cover the desired range of speed for the model. As a result of these preliminaries it was deemed advisable to make five tests on each set of ends with the model loaded and four tests on each set with the model empty.

[3] Theoretical Naval Architecture, by E. L. Attwood, p. 318.

The ends when placed on the body of the model were connected to the lug on the bottom of the vertical arm by a short, heavy wire to prevent jerking the model. The model was loaded until it had a freeboard of just one inch. This corresponded to a 4-ft. freeboard on the full-sized barge. The level of the water in the flume was then raised until the wire connecting the model to the load arm was horizontal, so that the scales would indicate the horizontal pull on the model.

In making tests the car was pushed as nearly as could be at a speed at which the scales were balanced for as great a portion of the length of flume as possible. For a run to be satisfactory it was necessary for the scale pen to indicate that the scales were balanced for a distance of at least 16 ft. when the speed of the car was constant. This was indicated when the scale pen traced a straight line with no "bumps" or knobby protuberances in it while the distance or space pen was making three bumps in its curve. At the same time it was necessary that the distances between the first and second and the second and third bumps in the line traced by the

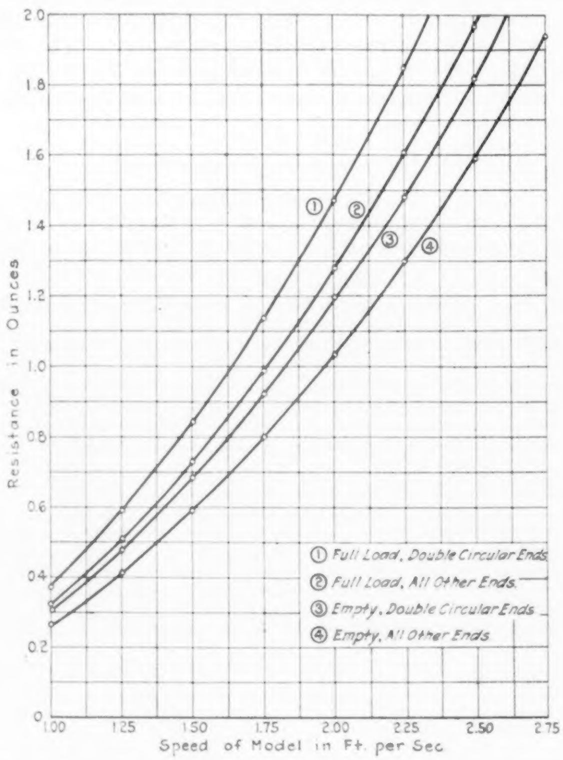


FIG. 6 FRICTIONAL RESISTANCE OF MODEL AT VARIOUS SPEEDS

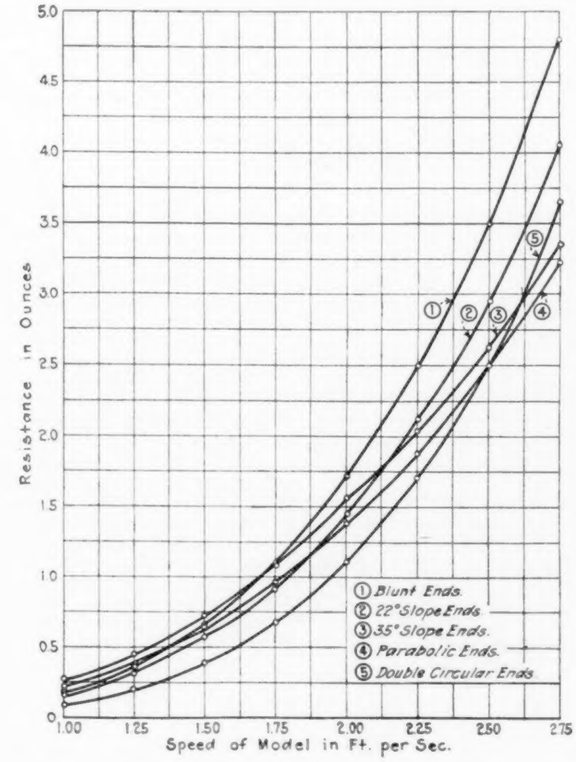


FIG. 8 EDDY- AND WAVE-MAKING RESISTANCE OF MODELS (EMPTY)

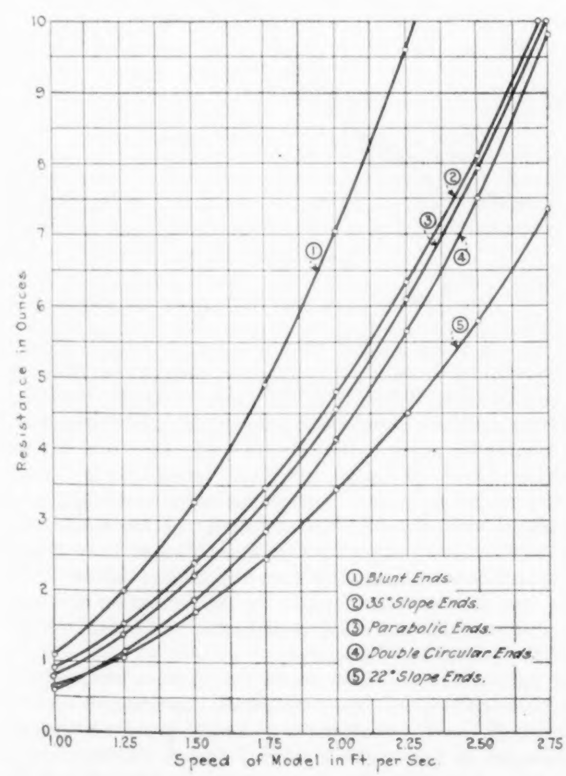


FIG. 7 EDDY- AND WAVE-MAKING RESISTANCE OF MODELS (LOADED)

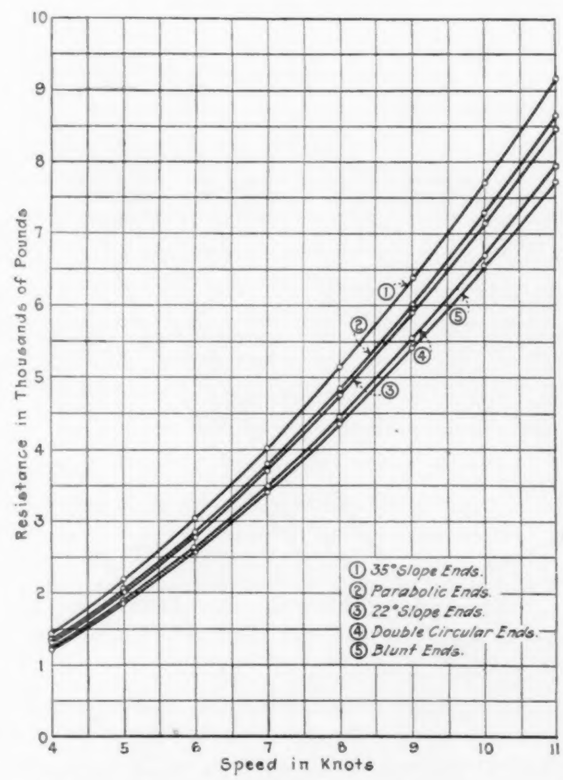


FIG. 9 FRICTIONAL RESISTANCE OF SCOWS (LOADED)

distance pen be the same. A sample chronograph sheet is shown in Fig. 13. The spaces where the above conditions for a satisfactory run were met are indicated by the small double arrowheads and circles.

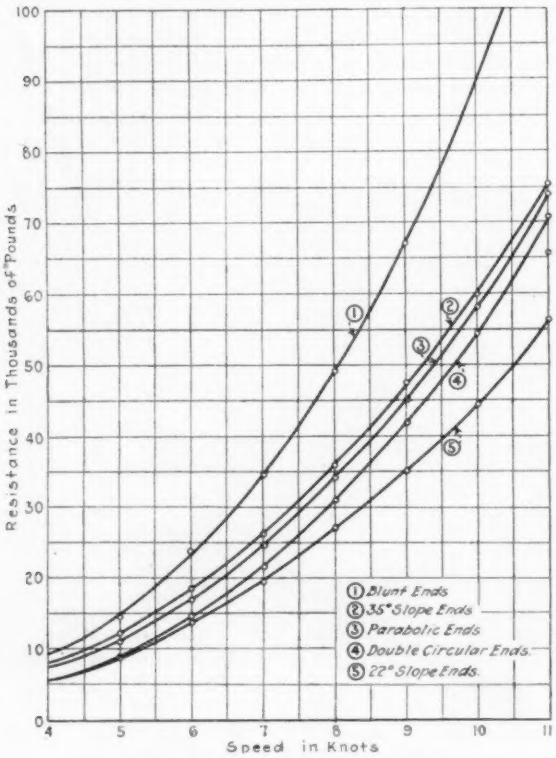


Fig. 10 Total Resistance of Scows (Loaded)

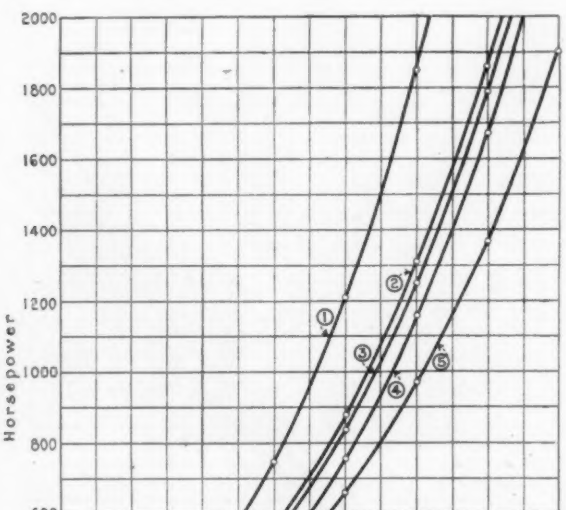


Fig. 11 Tow-Rope Horsepower of Scows (Loaded)

The space between these arrowheads is the part of that run which was used in the computations. It will be noted that the scale pen has not traced a perfectly straight line between these points, but that there are a few small bumps in it. These bumps were due to the fact that it was almost impossible to keep the contacts on the scales from touching on account of the jar caused by certain irregularities in the track on which the car moved, and not because the scales were unbalanced. At least two runs were made on each test for the purpose of furnishing an approximate check on their correctness.

At the end of the run the stop string running along the side of the flume was pulled. This opened the clock switch and also released the trip which stopped the chronograph drum. The switches on the scales and side contact were then opened on the car, after which the model and car were taken back and pu tin readiness for another run.

Calculation of Results

Curves of the frictional resistance of the model at various speeds were computed and plotted as shown in Fig. 6. As a result of constructing the model so that the deck projected beyond the body, it was necessary to construct the double circular ends in a way that added a relatively large area of surface to the body of the

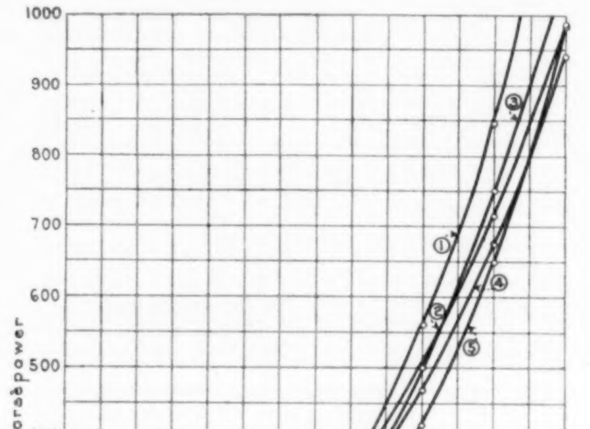


Fig. 12 Tow-Rope Horsepower of Scows (Empty)

scow. It was therefore felt that this extra resistance could not fairly be charged to the ends themselves, and so curves of the frictional resistance of the body of the model with the increased surface were plotted for these ends. Because of the increased length of the model, the value of the friction coefficient *f* and the velocity exponent had to be changed, as well as the surface in the formula for the frictional resistance. After the speed and total resistance of the model were obtained for each test, the frictional resistance at the speed of the particular test was obtained from the proper curve, and this was subtracted from the total resistance. The remainder was the resistance caused by the formation of waves and eddies, and was directly chargeable to the particular pair of ends used in the test under discussion.

After the resistances of the model due to wave and eddy formation at the various speeds were computed, these results were plotted on logarithmic cross-section paper to secure greater accuracy, and then replotted in the curves of Figs. 7 and 8. A curve of corresponding speeds for model and scow was also plotted and used in transferring the wave and eddy resistance of the model to the full-sized scow.

Since the different pairs of ends have more or less widely varying displacements, in order to effect a true comparison of their efficiencies it was necessary to assume some standard displacement to which all of the scows could be reduced. This was assumed at 2500 tons,

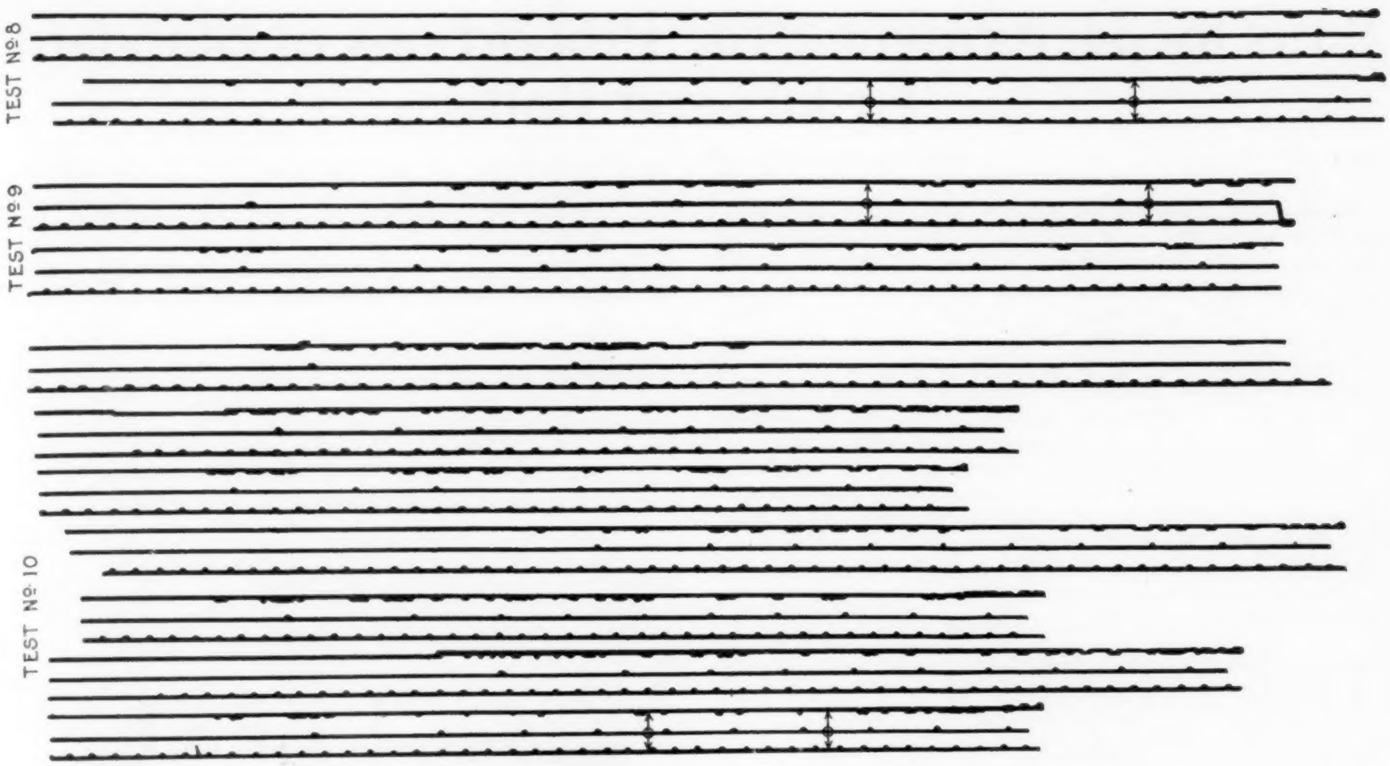


Fig. 13 Sample Chronograph Sheet

and the corresponding body lengths to give this displacement with each pair of ends were determined. From these lengths the surfaces—and from them the frictional resistances of the scow at various speeds when equipped with the several differently shaped ends—were determined and plotted (Fig. 9).

It is to be noted that the friction coefficient f' is also different in the frictional-resistance formula when used for the different body lengths.

To these curves were added the wave- and eddy-formation resistances of the corresponding ends at the same speed. These resistances were taken at the corresponding speeds and multiplied by the cube of the scale ratio before being added. The curves of total resistance of the scow thus obtained were plotted (Fig. 10), and from this curve the tow-rope horsepower at the various speeds was computed and plotted (Fig. 11).

A similar process was gone through in order to obtain the horsepower required in towing the empty scow (Fig. 12).

The data for the models and the full-sized scows are presented in Table 1.

Conclusions

The curves of Figs. 11 and 12 furnish the real material from which the conclusions reached in this investigation are drawn.

The first thing shown by these curves is that at low speeds the shape of end used on a loaded scow is of very little consequence as far as efficiency is concerned. But above a speed of 4 knots the horsepower required by the various ends at the same speed is considerably different, the difference increasing materially as the speed is increased.

There seems to be little choice between the parabolic, the 35-deg.-slope, and the double circular ends at all speeds. However, the double circular ends seem to be somewhat better than the other two. On the other hand, the blunt ends offer far and away the greatest resistance of any of the shapes, and the 22-deg.-slope ends are much superior to any of the others, except in the case of the double circular ends at speeds up to four knots.

It is interesting to note in this connection that the blunt ends are of the general type almost universally used on scows at the present time. The horsepower required at all speeds by the blunt ends is very nearly 100 per cent greater than the power required by the 22-deg.-slope ends at the corresponding speeds.

The results shown in Fig. 12 for the empty scow do not show the striking differences between ends indicated in the curves for the loaded model. An interesting peculiarity is that for the empty scow those ends which require the fewest horsepower at the lower speeds require the most horsepower at the higher speeds. A possible explanation of this peculiarity is that it is caused by the interference of the wave form with the end of the model as the speed is increased. In the case of the blunt ends, for example, at the lower speeds only a very small wave is formed, and on account of the bottom shape of these ends they act more like the double circular ends. As the speed is increased, however, this wave form becomes considerably larger, and in so doing rises in the front of the scow so that more of the end is submerged in the wave and consequently the end has the effect again of the blunt type.

An opportunity offers itself in this connection for some interesting experiments on the effect of backwash from a tug. In these a small propeller would be placed just forward of the model and be driven at such a speed that the backwash from a tug would be approximated for the model. The effect of the first scow on those following in a towing line might also be readily investigated.

TABLE 1 DATA ON MODELS AND SCOWS

(Scale of model: 1/4 in. = 1 ft. All models loaded to 1 in. freeboard. All models empty have 2 3/4 in. freeboard.)

All Ends Except Double Circular:

Length of body of model = 38.5 in.
Surface of body of model = 4.95 sq. ft. (loaded)
= 4.01 sq. ft. (empty)
Friction coefficient (f) = 0.382

Double Circular Ends

Length of body of model = 44.5 in.
Surface of body of model = 5.71 sq. ft. (loaded)
= 4.64 sq. ft. (empty)
Friction coefficient (f) = 0.381

Surface of Scow, Sq. Ft.:

	Type of End				
	Parabolic	Double circular	22-deg. slope	35-deg. slope	Blunt
Loaded...	11,950	10,990	11,700	12,680	10,750
Empty....	9,680	8,900	9,480	10,290	8,720

Displacement of Scow, Assuming Standard Displacement of 5,000,000 Lb.:

Type of end	Corresponding displacement, lb.	Change in length for standard displacement, ft.	Body length, ft.	Coefficient f'
Parabolic	4,780,000	+ 7.4	161.4	0.00907
22-deg. slope	4,880,000	+ 4.04	158.04	0.00908
35-deg. slope	4,490,000	+17.2	171.2	0.00906
Double circular	5,880,000	−29.6	148.4	0.00909
Blunt	5,260,000	− 8.75	145.25	0.00909

Basis for Determining the Proportions of Standard T-Slots and Bolts

By LUTHER D. BURLINGAME,[1] PROVIDENCE, R. I.

For many years forward-looking engineers have urged the standardization of the holding elements of machine tools, such as T-bolts and slots. The importance of such standardization has been generally recognized, not only by individual manufacturers but by the National Machine Tool Builders' Association, the technical societies, and the American Engineering Standards Committee. This has resulted in the appointment of a sub-committee which for several years has been at work on the problem of providing an acceptable standard for T-slots such as are used in the tables of machine tools. A standard has now been formulated by the committee and is the subject-matter of a report presented at this meeting.

A great amount of material has been collected showing past and existing practice. Tests have been conducted to ascertain the comparative strength of bolts and slots, in order that the proportions submitted might be suited to practical needs. That the report of the committee may not be loaded with the records of this investigation but may instead be concentrated on the actual proportions to be adopted, that report is supplemented by this record of the underlying investigations on which it is based.

THE elements of possible weakness which might result in failure of T-bolts, slots, and nuts, and which were investigated, are as follows:

T-Slots

a Denting or compressing metal under heads
b Springing or breaking lips

T-Bolts

a Deformation or breakage of lips of head
b Pulling off of head
c Breaking bolt through body
d Breaking bolt at roots of thread
e Stripping threads of bolt or nut

T-Nuts

a Stripping threads
b Deformation or breakage of lips of nut
c Buckling by bending at tapped hole.

Other Factors to Be Considered

Working clearances should be such as to give ample space (1) for oil and chips between the head of the bolt or the T-nut and the T-slot; (2) for clearance for the body of the bolt to slide freely in the throat of the slot even if the bolt is of maximum size or the slot is bruised; (3) for allowance for regrinding cutters used in machining T-slots; and (4) for allowance for machining the worn or bruised surface of table.

Methods of Investigation

A study was made of these varying conditions, and correspondence was carried on with manufacturers of machines and users of equipment requiring T-slots. This included a study of standards in use in foreign countries. Also a series of tests was made, using milling-machine tables made of cast iron of varying degrees of hardness, bolts of varying tensile strength, and T-nuts with tapped holes for varying sizes of studs.

Milling-machine tables made of "hard" cast iron, such as are regularly made by the Brown & Sharpe Mfg. Co. and other milling-machine manufacturers for this purpose, were used for one series of tests. An analysis of the composition of these tables follows:

Silicon	1.25–1.50
Sulphur	0.11–0.14
Manganese	0.55–0.70
Phosphorus	0.35–0.45
Total carbon	3.20–3.60
Combined carbon	0.75–0.85

In the other series of tests the tables were made of gray iron, often called "soft" cast iron, with an analysis as follows:

Silicon	1.90
Sulphur	0.09
Manganese	0.60
Phosphorus	0.50
Total carbon	3.45
Combined carbon	0.60

The terms "hard" and "soft" cast iron used in this paper will be understood to be in correspondence with these analyses. These tests were made at the Brown & Sharpe works, and at the engineering laboratory at Brown University.

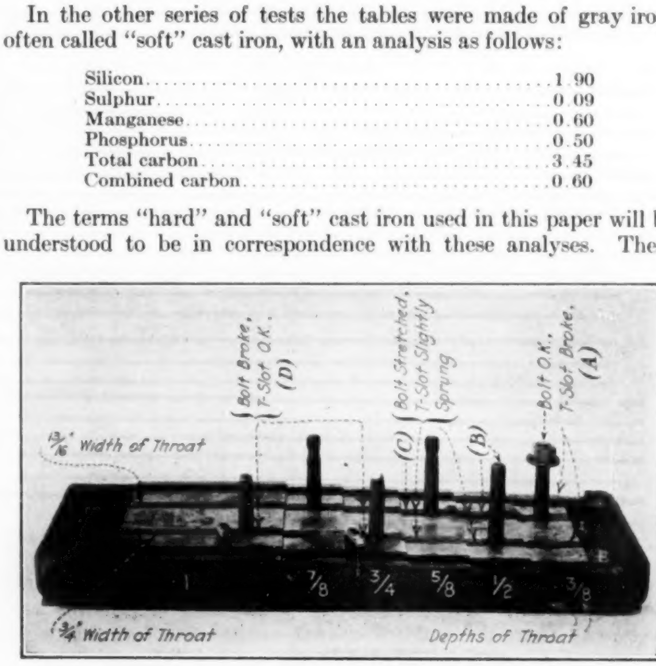


Fig. 1 Tests to Ascertain Comparative Strength of $3/4$-In. T-Slots and Bolts
(Table of hard cast iron.)

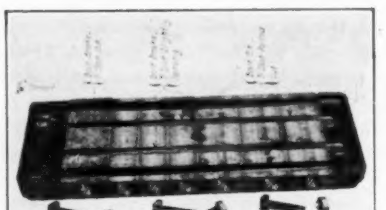


Fig. 2 Tests to Ascertain Comparative Strength of $5/8$-In. T-Slots and Bolts
(Table of hard cast iron.)

Each of these tables had two T-slots machined in it. In the tables for $3/4$-in. bolts the throat of one slot was $3/4$ in. wide and that of the other was $13/16$ in. wide. In the tables for $5/8$-in. bolts the throat of one slot was $5/8$ in. wide, and of the other, $11/16$ in. The surface of each of these tables was machined in steps so as to provide different depths of T-slot for the purpose of making tests to show the comparative strength of the bolt and the lip of the T-slot. Fig. 1 shows a table made of hard iron for $3/4$-in. T-bolts having a depth of throat varying from $3/8$ in. to 1 in. by eighths, and illustrated the condition of bolt and slot after the test was carried to the point of destruction.

Fig. 2 shows a similar table of hard iron with slots for $5/8$-in. bolts, the throats being $5/8$ and $11/16$ in. wide, respectively, and the depth of slot varying from $1/4$ to $3/4$ in., the variation being by $1/16$ in. up to and including $9/16$ in.

Tests of T-Bolts in Tables of Hard Iron

Tests were made on these tables by using case-hardened bolts and nuts of the B. &. S. standard,[2] the T-bolts being finished from forgings made of No. 2 bolt steel having an analysis as follows:

[1] Industrial Superintendent and Patent Expert, Brown & Sharpe Mfg. Co. Mem. A.S.M.E.

Contributed by the Machine Shop Practice Division and presented at the Providence, R. I., Meeting, May 3 to 6, 1926, of The American Society of Mechanical Engineers.

[2] Heads of $3/4$-in. bolts $1^1/_4$ in. across flats and $1/2$ in. thick; of $5/8$ in. bolts, $1^1/_8$ in. across flats and $3/8$ in. thick; diameter of bolts 0.024 in. less than nominal diameter for both sizes.

Carbon	0.10–0.15
Manganese	0.25–0.35
Phosphorus	0.04
Sulphur	0.06
Silicon	0.15

These tests were made with the surface above the T-slot where the strain was exerted unsupported, that is, there was no metal-to-metal clamping. The T-slot was therefore left in this respect in the weakest condition in which it might be used.

In order to secure sufficient leverage to carry out these tests an extension pipe was put on the handle of the standard wrench as shown at *A* in Fig. 3, but the wrench itself would not stand this abuse and broke in service. A bar of steel (*B*) having hexagonal openings to fit the nuts was then substituted. With this latter combination each test could be carried to the point of breakage either of the lip of the T-slot or of the bolt. In the case of the $^3/_4$-in. bolt with the throat $^3/_8$ in. deep, the metal of the lip of the T-slot was pulled out, the bolt remaining undamaged. (Shown at *A*, Fig. 1.) When the thickness of metal in the table was increased to $^1/_2$ in. the lips were sprung before the bolt gave out, but held sufficiently so that the bolt was stretched and would have broken before actually pulling out the metal of the table (*B*, Fig. 1.)

This, however, was on the border line and represented approximately equal strength of bolt and T-slot. With the metal of $^5/_8$ in. thickness the bolt was noticeably the weaker element and stretched as shown at *C* while only slightly springing the metal of the T-slot, this latter returning to normal condition as soon as the strain was relieved. With a thickness greater than $^5/_8$ in. the bolt broke without damaging or even noticeably springing the T-slot. (See *D*, Fig. 1.)

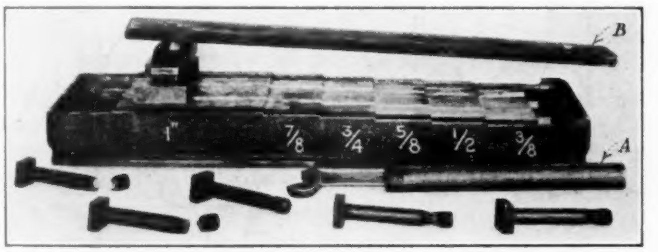


Fig. 3 Method of Making Tests

An effort was made to ascertain whether there was any difference between the strength of slots $^{13}/_{16}$ in. and $^3/_4$ in. wide. No noticeable difference could be observed, although in theory the $^3/_4$-in. slot should have been slightly stronger. Neither did the fact that with a width of throat of $^{13}/_{16}$ in. there would be less area of contact between the head and the under side of the lip of the slot develop any indication of denting or crushing the metal.

Similar tests were made with a $^5/_8$-in. bolt in slots having throats $^5/_8$ in. and $^{11}/_{16}$ in. wide. The results shown in Fig. 2 indicate that T-slot was weaker than the bolt up to and including throats $^3/_8$ in. deep, but that with throats $^7/_{16}$ in. or $^1/_2$ in. deep, conditions were fairly balanced although favoring the strength of the T-slot in both cases, because the bolt broke before the table was sprung to a degree beyond which it would not recover. With the lips thicker than $^1/_2$ in. the bolt broke without affecting the T-slot.

Tests were made with studs threaded at both ends for the purpose of learning whether the stud would always break at the same end, either at the upper or lower thread, and it was found that breakage would be sometimes at one end and sometimes at the other, but always through the threaded portion.

From these facts it will be seen that in hard iron the thickness of lip of the $^3/_4$-in. T-slot can be a minimum of $^9/_{16}$ in., which is practically equal in strength to the bolt or stud, while for the $^5/_8$-in. slot the thickness of $^7/_{16}$ in. can be established as minimum.

A study was also made of the strength of the head of the bolt. In no case did the head spring or show weakness in other ways. The nuts used with these bolts were of cold-rolled steel, 0.10 carbon, $^{11}/_{16}$ in. and $^9/_{16}$ in. thick, respectively. They showed no sign of damage or hard usage due to the tests, nor did their threads or the threads of the bolt on the portion engaging the nuts show deformation.

The conclusion to be drawn is that there is sufficient width of shoulder and thickness to the heads of the bolts to distribute the pressure on the under side of the lip of the T-slot so as to avoid denting or otherwise damaging it up to the point of rupture of the bolt; and later tests showed this to be so even when the bolt was made of steel of unusually high tensile strength. The further conclusion is drawn that with the throat of the slot $^1/_{16}$ in. wider than the diameter of bolt, the surface of contact is not reduced to a point where it is objectionable; also that the heads are sufficiently thick and strong to withstand the greatest strain which can be put upon them before the bolt breaks through the threads.

Comparative Tests Using Hard and Soft Cast Iron for Tables

The tests made to ascertain the comparative strength of T-slots milled in soft and hard iron were made under the direction of Prof. James A. Hall, of Brown University, and were directed both to the question of the comparative strengths of soft and hard cast iron

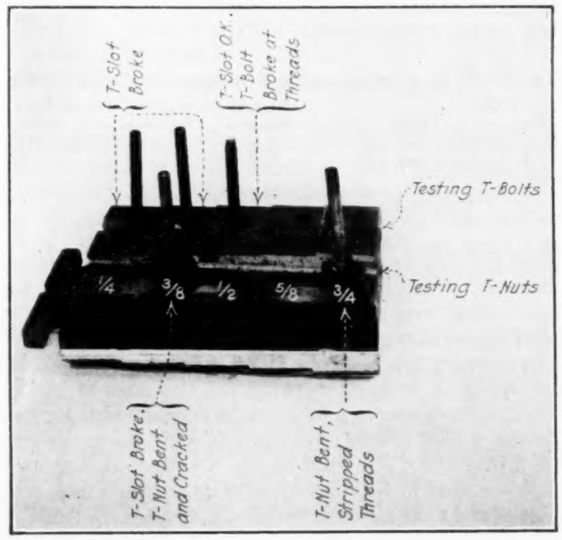


Fig. 4 Tests to Ascertain Strength of T-Slots in Soft Cast Iron and Between T-Bolts and Studs with T-Nuts

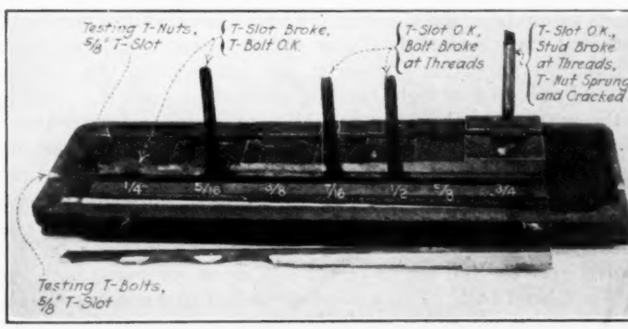


Fig. 5 Tests to Ascertain Strength of T-Slots in Hard Cast Iron and Between T-Bolts and Studs with T-Nuts

and to the comparative strength of T-bolts and T-nuts with their coöperating studs. (See Figs. 4 and 5, and Tables 1 and 2.)

The tests in hard iron showed practically the same results as for those already described. Thus for the $^5/_8$-in. T-slot, Table 2 shows that a throat $^7/_{16}$ in. deep provides lips stronger than the T-bolt, which broke under a load of 16,600 lb. A noticeable difference between the slots in hard iron and soft iron was that the soft iron not only began to spring but showed a permanent set after the removal of the strain under a lighter load than in the case of hard iron.

T-Nuts

When the ends of the T-slots are obstructed, or when it is desirable to insert additional holding devices after the work or attachment has been located, the heads of T-bolts are sometimes "slabbed off" as shown in Fig. 6 so as to allow the bolt to be entered through the throat of the slot. While this is a convenient method it is not

to be recommended, as it reduces the area of contact of the head with the lip of the slot to such an extent that it soon results in "chewing up" the under side of the lip.

For this purpose the use of T-nuts is preferable, although here also there is a drawback in that the tapped hole through the T-nut weakens it. If the tapped hole and engaging stud are of the same size as the T-bolt for the corresponding size of slot, the nut is weakened to such an extent that "buckling" may result and the strain may be brought on a limited area of the lip of the slot. The T-nut may buckle to such an extent that it will fail by stripping the threads of either the nut, the stud, or both, long before the limit of strength of the stud is reached. Although for the sake of uniformity the T-nuts are listed as being tapped for studs of the same diameter as the corresponding bolt, it can be recommended that, where maximum strength is required, the T-nuts be tapped for smaller studs, thus giving ample strength to the nut but reducing the force which can be applied in clamping by an amount equal to the difference in strength between the two sizes of stud. This use of smaller studs can in a measure be compensated for by using studs having a high tensile strength. It will be seen by referring to Table 2 that the 5/8-in. stud in No. 8 withstood a greater load than the 3/4-in. stud in No. 10 because of its greater tensile strength.

In most of the tests for T-nuts (Figs. 4 and 5, and Table 3) the stud and consequently the tapped hole in the nut were of the same nominal size as the bolt for the corresponding slot. They showed that the 5/8-in. nuts failed by buckling through the weakened portion tapped for the stud, and that this resulted in stripping the threads before breaking the stud. The condition of the nuts indicated that there was little if any added strength obtained from the upwardly projecting portion of the nut because this portion fractured as soon as a slight bending strain came upon it. Neither did the greater length of the nut, 1 11/16 in., provide a correspondingly increased length of bearing on the under lip of the T-slot, for when a strain was applied and before it had reached a point approaching the strength of the stud, the buckling of the nut brought most of the pressure at the center, thus tending to spring the lip of the T-slot under a much less strain than if the load were distributed over the full length of the nut, or as compared with the use of a T-head bolt. This weakness was not so much in evidence for the 3/4-in. nut in which the stud broke before noticeably bending or otherwise damaging the nut, although, if the tensile strength of the 3/4-in. stud had been in proportion to that of the 5/8-in size, it is probable that the nut would have given out first.[3]

Comparing the strength of the T-head with that of the T-nut, Professor Hall's tests Nos. 2 and 7 show that even though the nut is thicker and longer than the bolt head it is not stronger, if as strong, the limit of the strength of the T-head not having been reached in any of the tests because of the prior failure of the bolt, while the T-nut failed by stripping the thread after buckling the nut; and even in cases where the stud broke first the T-nut was deformed and its threads damaged before the stud broke.

The T-nuts and studs were provided for these tests by another manufacturer, and an analysis of their composition is not at hand; but in the case of one of the 5/8-in. studs its high tensile strength gave an opportunity to make a severe test on the lips of the 5/8-in. T-slots with throats 3/4 in. deep and showed that, even with a 30,250-lb. strain concentrated in the line of the stud center, the slot was not damaged because of the buckling of the nut.

In order to examine the condition of the slots after the tests had been made, sections of the tables were removed as shown in Figs. 4 and 5 so that the permanent springing of the metal could be measured and a microscopic examination of the surfaces which had been under pressure could be made. Professor Hall comments on these tests, made under his direction, as follows:

TABLE 1 COMPARISON OF HARD AND SOFT CAST IRON WITH VARYING DEPTHS OF THROAT, USING T-BOLTS

No.	Type	Kind of cast iron	Bolt size, in.	Depth of throat, in.	Breaking load, lb	Remarks
1	T-bolt	Soft	5/8	1/2	10,100	Lips of slot broke
2	T-bolt	Soft	5/8	5/8	14,300	Lips of slot broke
3	T-bolt	Soft	5/8	3/4	17,250	Bolt broke in threads
4	T-bolt	Hard	5/8	5/16	14,600	Lips of slot broke
5	T-bolt	Hard	5/8	7/16	16,600	Bolt broke in threads
6	T-bolt	Hard	5/8	1/2	17,300	Bolt broke in threads

TABLE 2 COMPARISON OF HARD AND SOFT CAST IRON WITH VARYING DEPTHS OF THROAT, USING T-NUTS AND STUDS

No.	Type	Kind of cast iron	Stud size, in.	Depth of throat, in.	Length of nut, in.	Breaking load, lb.	Remarks
7	T-nut and stud	Soft	5/8	5/8	1 11/16	14,500	Both slot and nut failed
8	T-nut and stud	Soft	5/8	3/4	1 11/16	30,250	Stripped threads of both stud and nut after "buckling" nut
9	T-nut and stud	Hard	5/8	5/8	1 11/16	19,400	Bolt broke in threads
10	T-nut and stud	Hard	3/4	1/2	2	28,400	Bolt broke in threads

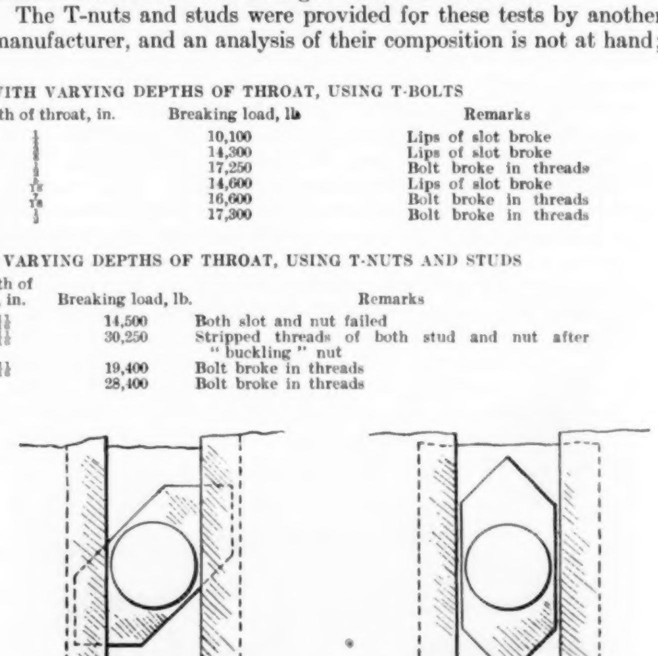


FIG. 6 BOLT HEAD "SLABBED OFF" SO THAT IT CAN BE WITHDRAWN THROUGH THROAT

[3] The thickness of the tongue portion of the 5/8-in. nut was 13/32 in., and of the 3/4-in. nut, 9/16 in.

TABLE 3 SHOWING APPROXIMATION OF SIZES TO GEOMETRICAL PROGRESSION AND MAXIMUM AND MINIMUM CLEARANCES FOR HEAD

STANDARD T-BOLTS AND SLOTS

Bolt or Stud						Bolt Head						T-Slot																	
Diameter		Area		Threads per inch		Across flats		Area of contact		Thickness		Width of throat		Depth of throat				Width of head space						Depth of head space					
																			Clearance			Clearance			Clearance			Clearance	
Fraction	Geo. progress	Sq. inch.	Geo. progress	Number	Geo. progress	Basic	Geo. progress	Sq. inch.	Geo. progress	Basic	Geo. progress	Basic	Geo. progress	Maximum	Geo. progress	Minimum	Geo. progress	Maximum	Max.	Min.	Minimum	Max.	Min.	Maximum	Max.	Min.	Minimum	Max.	Min.
1/4	0.25	0.049	0.049	20	20	15/32	0.47	0.088	0.09	5/32	0.16	9/32	0.28	3/8	0.38	1/8	0.13	9/16	1/8	3/32	1/2	1/16	1/32	11/64	3/32	5/64	11/64	1/16	3/64
5/16	0.32	0.077	0.077	18	17.3	9/16	0.58	0.122	0 13	3/16	0.20	11/32	0.35	7/16	0.46	5/32	0.17	23/32	1/8	3/32	19/32	1/16	1/32	15/64	3/32	5/64	13/64	1/16	3/64
3/8	0.39	0.110	0.12)	16	14.9	11/16	0.72	0.172	0.20	1/4	0.20	7/16	0.43	9/16	0.56	7/32	0.23	27/32	1/8	3/32	23/32	1/16	1/32	21/64	3/32	5/64	17/64	1/16	3/64
1/2	0.49	0.196	0.190	13	12.7	7/8	0.88	0.350	0.30	5/16	0.34	9/16	0.54	11/16	0.69	5/16	0.30	31/32	1/8	3/32	27/32	1/16	1/32	25/64	3/32	5/64	21/64	1/16	3/64
5/8	0.62	0.307	0.295	11	10.9	1 1/8	1.08	0.493	0.45	13/32	0.43	11/16	0.66	7/8	0.85	7/16	0.40	1 1/4	5/32	1/8	1 3/32	3/32	1/16	31/64	3/32	5/64	27/64	1/16	3/64
3/4	0.77	0.442	0.460	10	9.4	1 5/16	1.33	0.660	0.64	17/32	0.56	13/16	0.82	1 1/16	1.04	9/16	0.52	1 15/32	3/16	5/32	1 9/32	3/32	1/16	5/8	1/8	3/32	17/32	3/32	1/16
1	0.96	0.785	0.730	8	8.1	1 11/16	1.65	1.06	1.01	11/16	0.72	1 1/16	1.04	1 1/4	1.28	3/4	0.70	1 27/32	3/16	5/32	1 5/8	3/32	1/16	53/64	11/64	9/64	11/16	1/8	3/32
1 1/4	1.20	1.14	1.55	7	7	2 1/16	2.05	1.55	1.54	15/16	0.92	1 5/16	1.28	1 9/16	1.59	1	0.94	2 7/32	3/16	5/32	2 1/8	3/32	1/16	1 3/32	3/16	9/64	1 1/32	1/8	3/32
1 1/2	1.50	2.33	2.33	6	6	2 1/2	2.50	2.33	2.33	1 3/16	1.19	1 9/16	1.56	1 15/16	1.93	1 1/4	1.25	2 21/32	3/16	5/32	2 9/16	3/32	1/16	1 11/32	3/16	9/64	1 9/32	1/8	3/32

The area of bolt head taking the thrust is about 0.48 sq. in. in the case of the $^5/_8$-in. T-bolt size and 0.78 sq. in. for the T-nut. At first thought it might seem that the latter would give a higher breaking load for a given size of slot, but this is not appreciably so, as shown by a comparison of tests No. 2 and No. 7.

An analysis of the distribution of the forces on the T-nut shows that the bending moment at the center must be large if any considerable pressure is to be carried by the outer ends of the nut. As the cross-section of the T-nut at the center is greatly reduced due to the hole for the stud, the stresses due to bending at this point are apt to be very large. This was calculated, the pressure being assumed to vary uniformly from zero at the ends of the nut to a maximum at the center, and the result showed that the elastic limit of the steel of the nut would be reached long before a normal pressure could be carried by the outer ends of the nut in practice, and that practically all of the thrust was taken at the center. It is only after the slot has begun to break that the ends are under any considerable pressure. For this reason it is the opinion of the writer that these T-nuts would be stronger and more satisfactory if they were shorter.

In all cases where the pressure was not sufficient to crack or break the slot, and where the bolts therefore broke at the root of the threads, there was no appreciable crushing of the cast iron under the bolt heads, indicating that the crushing strength of the cast iron was not reached.

Progress Report and Questionnaire

A progress report and questionnaire prepared under the direction of the committee were sent out to a selected list of manufacturers of machinery using T-slots and to users of such machinery. The questions were:

1 As to the sizes of T-bolt and slots to be made standard
2 and 3 As to the size of head of T-bolt and the clearance to be allowed
4 and 5 As to whether the width of throat should be (*a*) equal to the nominal diameter of bolt; (*b*) wider than the nominal diameter of bolt, and if so how much; and (*c*) whether optional either (*a*) or (*b*) so as to provide for extensive present practice, at least during a transition period.

Of the forty-five who replied, some gave their present practice and others the practice which they recommended, even though it might not accord with what they were using. The replies can be classified under the following heads:

1 Recommended sizes to be standardized
2 Proportions of head and head space
3 Width of throat
4 Depth of throat.

Recommended Sizes to Be Standardized

While there was a general acceptance of the sizes proposed by the committee, a number of those replying believed that some of these sizes could be eliminated by leaving out the smaller sizes and beginning the series with $^3/_8$ to $^1/_2$ in. Other suggested leaving out some of the intermediate sizes, such as $^5/_{16}$, $^7/_{16}$, and $^7/_8$ in. The geometrical sizes to which the proposed standard conforms accord closely with some of these suggestions. The sale of T-slot cutters has indicated that there is widespread demand for the smaller sizes, so they have been included.

Proportions of Head and Head Space

While the majority of replies showed that the proportions based on the use of commercial T-slot cutters were generally acceptable, those who did take exceptions asked for greater thickness of head and for more clearance space, especially at the bottom of the slot, so that the bolt head would slide freely even when the slot was obstructed by oil and chips, and so as to provide better for the use of T-nuts. An additional reason given was that the size of slot should be made to receive the heads of commercial bolts such as can be obtained in the market.

Conceding that more clearance is desirable, one of two methods for securing this seemed possible of adoption; either to make the heads smaller, continuing to use the commercial T-slot cutters, or to increase the size of slot, thus requiring new cutters. The latter plan was adopted and the size of slot has been increased so as to allow for somewhat thicker heads, especially for the smaller sizes of bolts. This has the objection that some heads of the new proportions cannot be used in present T-slots. Many manufacturers may for this reason choose to continue to make the heads of their T-bolts thinner than standard, using material of sufficiently high tensile strength to insure the desired strength so that the bolt heads can be used in either the shallower or deeper head space.

Width of Throat

It is generally conceded that this is the most important dimensions affected by standardization, and also the one which it is most difficult to standardize because of the importance of interchangeability with past product. An analysis of the replies to the questionnaire shows that there are

13 in favor of making the throat width the same as the nominal diameter of bolts, and
32 using and presumably recommending a wider throat.

These latter, to whom may be added 4 who express willingness to change, can be grouped thus:

a Those favoring having the throat $^1/_{16}$ in. wider than the diameter of bolt, of whom there were 23
b Those favoring having the small sizes (usually $^1/_4$-in. and $^5/_{16}$-in.) $^1/_{32}$ in. wider and all other sizes $^1/_{16}$ in. wider, of whom there were 9
c Those favoring having the larger sizes $^1/_8$ in. or more wider, of whom there were 4.

The forty-five replies received came from 34 machine-tool builders, 4 machine users, 3 technical societies, and 4 professors and mechanical engineers. The thirteen who were milling-machine manufacturers divided into 7 using throat widths equal to the nominal diameter of bolt, and 6 using wider throat widths, or, when including 2 of the first group who expressed themselves as willing to change, 5 for a narrower and 8 for a wider throat.

Depth of Throat

The depth of throat is the least important dimension to standardize. Where slots are used for strapping down work or for any other purpose where the strain comes on the lips of the slot unsupported, a greater depth is required than in such cases as those of clamping down a vise or clamping "dog bolts," where the parts are clamped together, metal to metal. In cases where T-cutters are used it is desirable to specify a maximum depth, as the length of the neck of the cutter determines the depth which can be milled. Specifying a minimum depth provides a safeguard against venturing on "too thin ice."

Comparison with Foreign Standards

In comparing the proposed American standard with T-slot standardization abroad, the practice in Great Britain and Germany can be taken as typical.

British Practice

In Great Britain, the standard for T-slot cutters published by the British Engineering Standards Association, July, 1920, lists sizes from $^1/_4$ in to $1^1/_2$ in. and provides for two widths of throat, these being in accord with the widths proposed for the American standard when including the supplementary width recommended on account of present extensive use and having the throat width of the same nominal width as the diameter of bolt or stud. In this respect, therefore, the product of the two countries would be interchangeable for each width, and, with provision for reversible tongues, fully interchangeable. The British standard provides for slightly deeper head space and greater maximum depth of throat than the American standard.

Relative to the use in Great Britain of a width of throat greater than the diameter of bolt, information was received from the British Engineering Standards Association under date of July 15, 1924, to the effect that in British practice the slots are usually made of the greater width, and the further statement is made that the T-slots were standardized on the assumption that T-headed bolts would be used. This appears to be the general practice in that country, although it is stated that there is nothing to prevent T-nuts being used if desired.

Broadly speaking, the fixtures and tools adapted to be used on machines of British make and fitted to British standard T-slots can be used on American machines made to the proposed American standard, without change. This includes the use of holding bolts or holding studs and T-nuts. The reverse of this is also true,

namely, that fixtures and tools adapted to be used on machines of American make and having standard T-slots can be used without change on machines of British make.

In some cases in either instance reversible tongues might be required, and perhaps spacing washers to provide for slight variations in the length of bolts.

German Practice

German standardization, as shown in DIN 650 based on the metric system, provides for a less depth of head space than the American standard, except for the smallest sizes, thus bringing the American standard between the German and British for the sizes most generally used.

In adapting to machines having metric T-slots as in the German practice, reversible tongues would be required. In the case of the bolts or studs, however, in German practice bolts made to the inch system, Whitworth standard, are commonly used. Such bolts or studs could be used interchangeably with both British and American standard T-slots.

Determining a Standard

Having ascertained that proportions such as indicated by the tests here described were in accord with average American practice and after comparison with the established practices of other countries, it was decided by the committee to limit the sizes standardized to those listed in Table 3 which provides a series approaching very closely to a geometric progression of sizes. After establishing the various dimensions for the smallest and largest sizes on the basis of the above findings, the intermediate sizes were graded in approximate geometric progression, as shown in Table 3.

The general demand for a greater amount of clearance space, for more room for chips and oil, and for sufficiently large slots to use commercial bolts and have their heads enter the slots, constituted a sufficient reason in the minds of the committee for departing from the established standard of T-slot cutters. This was done with more willingness because the simplified schedule of stock cutters, adopted in coöperation with the Department of Commerce, no longer lists these cutters as standard. It is believed that the proposed sizes should be obtained as readily, and at the same prices, as those formerly listed.

Fig. 7 illustrates the relation of the 3/4-in. bolt to its T-slot by showing both the maximum and minimum clearances, also the extremes in depth of throat, and can be taken as typical of the entire series of sizes.

As this paper is intended to supplement the forthcoming report

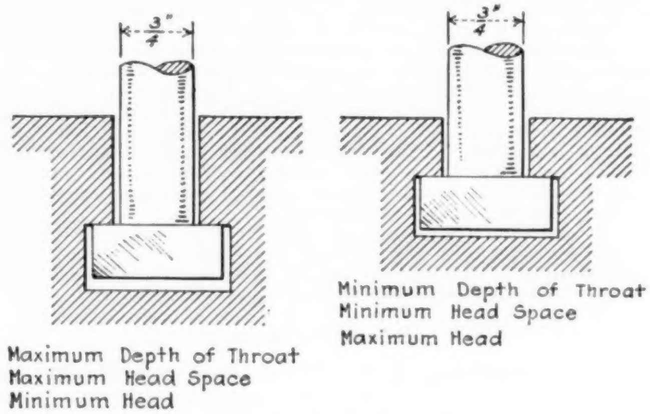


Fig. 7 Maximum and Minimum Depth of Throat and Clearances, 3/4-In. T-Bolt

of the Society's T-slot committee, reference is therefore made to that report for such matters as are not here fully discussed.

* * * *

Following the presentation of the paper, B. P. Graves[4] asked whether it had been definitely decided to make the slot wider than the bolt, or whether the present standard could be employed, such as used at Brown & Sharpe's, with the slot nominally the same size as the bolt.

In reply Mr. Burlingame said that the committee's report suggested that the wider throat be used as standard, but that during the transition stage the narrower throat would be recognized as a supplementary standard. In other words, manufacturers could use the narrower throat and still come within the standard. But he hoped that there would be uniformity of practice eventually.

[4] Milling-Machine Engineer, Designer, Brown & Sharpe Mfg. Co., Providence, R. I. Mem. A.S.M.E.

Examples of Size Determination

By E. R. Hedrick,[1] Los Angeles, Cal.

The determination of sizes in a scientific manner is one of the important phases of the general effort toward the elimination of waste in industry. Much has been written about the waste of material and of effort in the production of unnecessary sizes, and in the bad arrangement of size scales. To fit the sizes of articles of any sort to the needs of the consumers, attention must be paid the fundamental laws of psychology which direct the desires and demands of those consumers. To provide sizes for which the consumer feels no desire, or to fail to provide the sizes he does desire, is to waste effort and to misdirect production.

The underlying principle is that our senses perceive changes not to their absolute amounts but rather in proportion to the magnitude of the quantities we are observing. This law of psychology, known as the Weber-Fechner law, applies to all human feeling for amounts. It really goes far beyond the feeling for changes in dimensions of tangible objects; thus the ear will detect a change of a hundred vibrations per second on low notes of music more readily than on high notes; the magnitudes of stars were gaged by primitive peoples so that differences in brightness are called *noticeable* not when they are the same but rather when they are in the same proportion to the brightnesses under examination. But if this fundamental law of psychology applies to all our senses, it applies most emphatically to all observation of actual geometric size of tangible objects.

Attention has been called by many writers to cases in industry in which sizes of articles varying all the way from druggists' bottles to steel wire have been adjusted by long experience and by the harsh laws of demand and supply into a scale at least approximately in agreement with the psychological law mentioned above, i.e., approximately in geometric progression. Other instances have been cited, such as the sizes of shoes and the "penny" scale for nails, in which proper size adjustment has not been made.[2]

Engineers may take it for granted that the same reasoning and methods of analysis apply also to products which are of more direct interest to them than druggists' bottles, shoes, and nails. Thus F. J. Schlink, writing in the *S.A.E. Journal* on the use of preferred numbers, lists steam engines, machine tools, electrical machines, rolled shapes, ordnance, small tools, telephones, handwheels, etc. as material for similar consideration.

In what follows the author presents as examples of size determinations two widely different products: heavy safes and cranes.

The first example has been selected because it is an excellent illustration of a case in which size adjustment has proceeded according to a kind of commercial evolution, in an article of not too technical a kind, since specialized technical products are of interest to a limited group only. Yet the heavy safes here considered constitute an article involving many considerations of form, weight,

[1] Professor of Mathematics, University of California. Mem. A.S.M.E.

[2] See, e.g., Hirshfeld and Berry, Size Standardization by Preferred Numbers, Mechanical Engineering, Dec., 1922.

convenience, etc., and therefore illustrate the application of these ideas to elaborate manufactured products. The Hall Company's heavy safes are further of interest because from a slight examination of its table of sizes (Table 1[3]) it is evident that no conscious effort has been made to adjust the sizes into any particular type of series.

The second example; that of crane sizes, while no better as an illustration of size determination, will perhaps appeal more strongly to engineers, although here also it will probably be agreed that no purposive engineering study was responsible for the rational and regular character of the series as it now stands.

Size Determination in Heavy Safes

It is evident that the linear dimensions are controlled by a variety

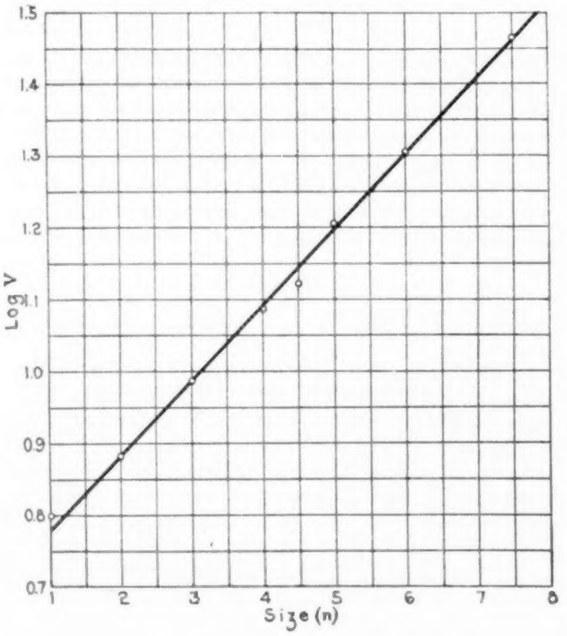


Fig. 1 Sizes of Bankers' Safes

of factors which render them useless for the purpose in hand. The really significant figures—those which would affect the purchaser's choice most—are the volumes, i.e., the inside capacities. To test these, we assume first, as in all such cases, that an ideal arrangement would show successive sizes in geometric progression, with a fixed ratio r. For size No. n,

$$V = kr^n, \quad \text{or } \log V = \log k + n \log r$$

The value of r taken by most authorities as a first standard[4] has been $\sqrt[10]{10}$, so that $\log r = 0.1$; but this value is not necessary for complete agreement with the psychological theory outlined above. It is only a convenient value, because every tenth size will come out ten times the original.

Applying this test to the series of bankers' safes (Nos. 914–921), we take the logarithms of the inside capacities, as shown in Table 2. If the sizes were regular, the differences between these entries should be constant. The differences are shown in Table 2 in the column marked $\Delta \log V$. The fourth, fifth, and seventh of these are very different from the others. But the *sum* of the fourth and the fifth is nearly equal to the others, and the seventh is close to 50 per cent above the others. This suggests that $V = 13.2$ is really an intermediate size, and that $V = 29.2$ is distinctly oversized. If we assign the size numbers as in the column headed n in Table 2, the agreement becomes remarkably good. This is borne out by the diagram of Fig. 1, in which the values of $\log V$ are plotted against the values of n. If the series were geometric, the graph should be a straight line, and its slope should be $\log r$. As a matter of fact, the points do lie nearly in line, the line drawn being one whose slope is 0.1062. This slope is the average slope omitting the first point and the last, which are most questionable.

[3] Taken from Frye's Civil Engineers' Pocket Book, 1918 edition, p. 816.

[4] See, e.g., F. J. Schlink, A New Tool for Standardizers, *American Machinist*, July 12, 1923.

TABLE 1 DIMENSIONS OF HEAVY SAFES

(Hall's Safe Company, Cincinnati, O. From Frye's Civil Engineers' Pocket Book, 1918 edition, p. 816.)

No.	Outside Dimensions: Height, in.	Width, in.	Depth, in.	Weight empty, lb.	Inside capacity, cu. ft.	Kind of safe
921	86.5	68.5	36	16080	29.2	
920	77.5	59.5	35	12530	20.2	
923	79	51	34	11100	16.0	
918	69.25	51	34	9650	13.2	For
922	73.5	45.5	34	8000	12.2	bankers
916	61	44	34	7270	9.7	
915	57	40	34	6200	7.6	
914	53	38	34	5380	6.3	
821	86.5	68.5	30	11000	28.4	
820	77.5	59.5	30	8900	21.2	
823	79	51	30	7900	18.3	
818	69	51	30	6400	15.1	
822	73.5	45.5	30	6300	14.1	For
819	69	38	30	5250	11.0	jewelers
816	61	44	30	4900	11.3	
815	56.5	39.5	30	4200	8.5	
817	61	34	30	4025	8.0	
814	53	38	30	3700	7.4	
521	86.5	68.5	34	8000	38.2	
520	77.5	59.5	32	6000	27.0	
523	79	51	32	5350	23.2	
518	69	51	30	5150	17.0	
522	73.5	45.5	30	4700	15.9	For
516	61	44	30	3650	12.7	general
519	69	38	30	3550	12.2	office
517	61	34	30	3200	8.9	use
515	57	40	29	3150	9.4	
514	53	38	29	2850	7.8	
512	55.5	34.75	29	2800	7.2	
513	49	36	28	2500	6.0	

It is therefore possible to arrange these safes into sizes so that they agree very well with the theory. Indeed, that there should be an intermediate size near the center of the series is quite reasonable; and it is also reasonable that the extreme sizes (the first and the last) should be somewhat off scale. If the sizes are recomputed, beginning with size 2, in a strictly geometric series, with $\log r = 0.1062$, the computed values are those shown in the columns marked $\log V'$ and V' in Table 2. The agreement between this com-

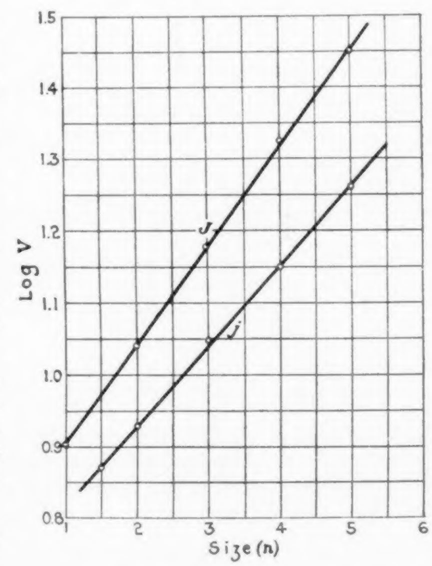


Fig. 2 Sizes of Jewelers' Safes

puted set of sizes in geometric progression and the actual manufactured sizes seems to the author to be remarkable if one takes into account that the sizes arose through business necessities independently of theory. In fact, the agreement of the ratio ($\log r = 0.1062$) with the ratio assumed in the standard accepted for the so-called "preferred-number" series ($\log r = 0.1000$) is quite remarkable under the circumstances.

Similar analysis of the series of jewelers' safes (Nos. 814–821) shows that there are in this series two independent sets, which the author has called sizes J_1, J_2, J_3, J_4, J_5, and j_1, j_2, j_3, j_4, j_5. That this arrangement into two sets is not visionary is demonstrated rather conclusively by Fig. 2, which shows the values of $\log V$ plotted against n, and also by the tabulated values given in Table 3, in which the columns have meanings similar to those of Table 2. Thus the recomputed values of V' are certainly surprisingly close to the actual values. The values of $\log r$ used are the slopes of the

TABLE 2 SERIES OF SAFES FOR BANKERS

(Assumed value of $\log r$ is 0.1062)

Catalog list number	Actual inside capacity V	$\log V$	$\Delta \log V$	Assumed size, n	Computed values, $\log V'$	Computed inside capacity, V'
914	6.3	0.79934		1	0.77451	6.00
915	7.6	0.88081	0.08147	2	0.88081	7.60
916	9.7	0.98677	0.10596	3	0.98701	9.75
922	12.2	1.08636	0.09959	4	1.09321	12.39
918	13.2	1.12057	0.03421	$4^1/_2$	1.14631	14.01
923	16.0	1.20412	0.07355	5	1.19941	15.83
920	20.2	1.30535	0.10123	6	1.30561	20.21
921	29.2	1.46538	0.16003	$7^1/_2$	1.46491	29.17

lines in Fig. 2; they are, for the J set, $\log r = 0.1376$, and for the j set, $\log r = 0.112$. It may be remarked in passing that the slightly larger value of r would seem to correspond to a reality, namely, that jewelers' demands in safes are not so accurately exacting as are the demands of bankers.

The third set of safes (Nos. 513–521) shown in Table 1 have also been computed and the corresponding figures drawn, but have not been included here. They show very nearly the same circumstances as the set of jewelers' safes; that is, there are in reality two series, with $\log r = 0.115$ approximately in each set.

Altogether, it seems to the author that the whole series of safe sizes developed in commercial practice show a very illuminating agreement with the psychological law mentioned at the beginning of this paper; and for very good reasons, since demands for such articles are based on very definite psychology. That the values for r actually found are not identical with the value recommended in the "preferred-number" series is hardly to be wondered at; it is indeed quite a surprise that the accidental values arrived at through manufacturing processes and commercial needs should be so near the recommended value.

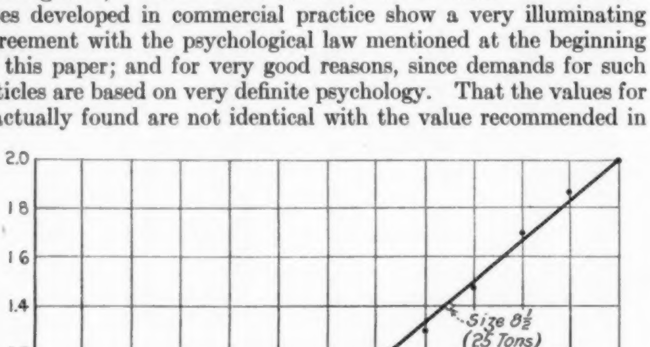


FIG. 3 SIZES OF CRANES

Analysis of Crane Sizes

A similar analysis has been applied to a series of crane sizes which appeared in *The Engineer* for December 4, 1925, p. 602, with the original serial numbers and lifting capacities in tons shown in the first two columns of Table 4. The series has been reconstructed according to the formula $t = ar^n$, where t = tons capacity, $a = 1$, $r = \sqrt[6]{10}$, and n = corrected size number. In Table 4 the logarithms of the lifting capacities in the original series, and of those corresponding to the reconstructed series are also given. In Fig. 3 the logarithmic straight line corresponding to the equation $t = ar^n$ has been drawn, and the logarithms of the lifts of the original series have been plotted with the new series numbers as abscissas. It is very interesting to note that the original crane sizes line up exceedingly well. The 25-ton size shows up very clearly as an interpolated half-size; and might be dispensed with more readily than any other of the series.

TABLE 3 SERIES OF SAFES FOR JEWELERS

(Assumed value of $\log r$ for J set is 0.1376; for j set, 0.112)

Catalog list number	Actual inside capacity, V	$\log V$	$\Delta \log V$	Assumed size, n	Computed values, $\log V'$	Computed inside capacity, V'
817	8.0	0.90309		J_1	0.90309	8.0
819	11.0	1.04139	0.13830	J_2	1.04069	11.0
818	15.1	1.17898	0.13759	J_3	1.17829	15.1
820	21.2	1.32634	0.14736	J_4	1.31589	20.7
821	28.4	1.45332	0.12698	J_5	1.45349	28.4
814	7.4	0.86923		$j_{1.5}$	0.87100	7.43
815	8.5	0.92942	0.06019	j_2	0.92700	8.45
816	11.3	1.05038	0.12366	j_3	1.03900	10.93
822	14.1	1.14922	0.11614	j_4	1.15100	14.25
823	18.3	1.26245	0.12323	j_5	1.26300	18.3

TABLE 4 SERIES OF CRANE SIZES

(Assumed series: $t = ar^n$, where t = tons capacity, $a = 1$, $r = \sqrt[6]{10}$, n = corrected size number)

Original serial number	t_1 = original tons lift	$\log t_1$	n = corrected size number	t_2 = lift corresponding to reconstructed series	$\log t_2$
1	1.00	0.000	0	1.00	0.000
2	1.50	0.176	1	1.47	0.167
3	2.00	0.301	2	2.15	0.333
4	3.00	0.477	3	3.16	0.500
5	5.00	0.699	4	4.65	0.667
6	7.00	0.845	5	6.81	0.833
7	10.00	1.000	6	10.00	1.000
8	15.00	1.176	7	14.68	1.167
9	20.00	1.301	8	21.53	1.333
10	25.00	1.398	8½	26.10	1.417
11	30.00	1.477	9	31.62	1.500
12	50.00	1.699	10	46.42	1.667
13	75.00	1.875	11	68.14	1.833
14	100.00	2.000	12	100.00	2.000

Conclusion

The articles considered in the above examples are of no petty kind. They are of interest to a wide range of people, and their manufacture is a serious case of practice. The author hopes, therefore, that this examination will serve a useful purpose in calling attention to the agreements with theory, and to the possibilities of analysis of data which may at first sight appear quite heteregeneous. The arrangement of such data into ordered series of graded sizes may prove of real value even when two sets are intermingled as in Table 1.

Rubber as a Resistant to Corrosion and Abrasion

IN A PAPER presented at a meeting of the Associated Technical Societies of Cleveland in May, B. W. Rogers and H. E. Fritz discussed the real effectiveness of rubber in resisting corrosion and abrasion, with special reference to grinding-mill linings.

While such properties of rubber as elasticity, resiliency, flexibility, dielectric quality, and moisture resistance are well-known and widely utilized, the authors say, its use in meeting corrosion and abrasion is very recent. Iron and steel possess great strength and many desirable physical characteristics, but do not meet the needs of many appliances from the point of view of corrosion, and in certain chemical manufacturing processes are entirely unsatisfactory from this point of view. Perfected forms of rubber, on the other hand, can resist without contamination all the acids except nitric, acetic, highly concentrated sulphuric, and phosphoric.

A good grade of rubber has also remarkable resistance to abrasion. Striking examples of this are to be found in the ordinary automobile tire; in rubber-covered belts used for carrying sharp abrasive ore; in the inch-thick rubber lining of a large grinding-mill shell in a cement plant, loaded with 45,000 lb. of steel balls, which showed no signs of wear after ninety days of continuous operation; in the rubber-covered bronze arms used in mixing finely divided abrasive material, and in many similar instances.

Rubber as a resistant to corrosion and abrasion becomes particularly useful when it can be effectively attached to metal more securely than by the use of cement or glue. By a process recently perfected in Akron and known as the Vulcalock process, adhesion between metal and soft rubber becomes so complete that the bond approaches the tensile strength of the rubber itself, in excess of 700 lb. per sq. in.

The process is now being employed in the lining of acid tanks and railroad tank cars and in the attachment of tubed or sheet rubber in standard steel pipes and fittings in such a way that all metal contact is eliminated, thus enabling them to resist abrasion and corrosion and to conduct liquids which are subject to contamination from metal contact.

But it has found an even greater application in lining ball grinding mills, where abrasive metalliferous ores have made the steel consumption in grinding excessive and costly. It has been used in Canada in mills grinding a hard quartz silver ore, and has made it possible to increase capacity without an increase in power consumption and without sacrificing the fineness of the discharge. Rubber lining is also now being adopted in the portland-cement industry for secondary wet-process grinding; in ceramic grinding because the contamination of white pigments is negligible; and in some chemical manufacturing operations where it is necessary to grind pigments in contact with corrosive liquors.

The Design of Dished Heads of Pressure Vessels

By S. W. Miller,[1] Long Island City, N. Y.

For a number of years the Union Carbide Corporation has been having made in commercial shops pressure vessels for some of its subsidiaries, using oxyacetylene welding for making the joints. These vessels have been carefully designed, the Boiler and Pressure Vessel Codes of the A.S.M.E. being followed in many respects, the important exceptions being that the design fiber stresses in these codes for welded joints were believed to be entirely too low, higher ones being used.

The first large ones were 7 ft. in diameter, of $^3/_4$-in. plate in the shell, the heads being 1 in. thick on the closed end and $1^1/_8$ in. on the manhole end. They were designed for 7000 lb. working fiber stress in the shell and 5600 lb. in the manhole head, using the formulas in Section P-197 of the Power Boiler Code, or U-38 of the Pressure Vessel Code, though in both cases a working fiber stress of 10,000 lb. is permitted.[2]

The Power Boiler Code, Section P-197, says that the inside corner radius shall not be less than $1^1/_2$ in. nor more than 4 in., and that within these limits it shall not be less than 3 per cent of the radius of the dished head.

The Pressure Vessel Code, Section U-38, provides that the corner radius shall not be less than three times the plate thickness up to $t = {}^1/_2$ in. For thicker plates the corner radius shall not be less than 3 per cent of the dish radius, and in no case less than $1^1/_2$ in.

The former rule has been interpreted by the Boiler Code Committee so that a larger radius than 4 in. is not forbidden.

The corner radius of these heads was 3 in., and the radius of the dish 84 in., so that the corner radius was within the limits of both codes.

Under test these heads showed heavy stress at the knuckle, but as this seemed to be due to the rounding out of some slightly flat spots left by the flanging, and as it was not serious at the working pressure, they were put in service. Recent measurements show that the stresses at the knuckle under working pressure are of the order of 11,000 lb. per sq. in., so it is considered that this part of the head is safe.

These heads also showed that there was a heavy stress at the long axis of the manhole, but they have given no trouble in service, and as there is no further evidence of distortion, even though the strain gage shows the stress to be larger than desirable, it is considered that the heads are safe, although the stresses are checked at regular intervals.

In designing the latest series of tanks a higher working fiber stress was used, 8000 lb. in the shell and 9000 in the heads, the Pressure Vessel Code being followed except for these stresses. (The code allows 11,000 in the heads.) These tanks were 5 ft. in diameter, for 300 lb. working pressure, and the shell was $1^1/_8$ in. thick, the solid head $1^1/_8$ in., and the manhole head $1^1/_4$ in. The general design of the tank is shown in Fig. 1. The corner radius of the heads was increased to 6 in. to avoid undue stresses at that point. The manhole flange contained about 25 per cent more metal than the Pressure Vessel Code calls for.

The manhole head was made of flange steel of the following properties according to the mill test:

Ultimate strength, lb. per sq. in.	57,440
Elastic limit, lb. per sq. in.	36,500
Elongation, per cent in 8 in.	30.25

Carbon, per cent	0.18
Manganese, per cent	0.42
Phosphorus, per cent	0.011
Sulphur, per cent	0.030

Its physical properties may have been somewhat altered by the flanging heat, which will be determined, if possible.

It was the intention to test the tank according to the Pressure Vessel Code on the basis of 9000 lb. working fiber stress, to see if this figure could be safely used in later designs. This corresponds to a working pressure of 337 lb. per sq. in. and a maximum test fiber stress of 27,000 lb. per sq. in.

The test was carried out in accordance with this program, strain-

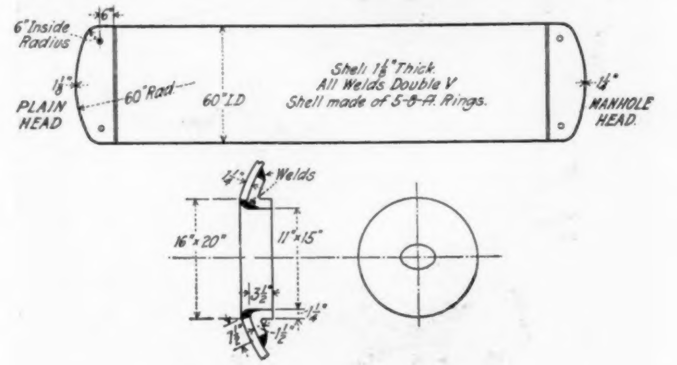


Fig. 1 General Dimensions of Tank

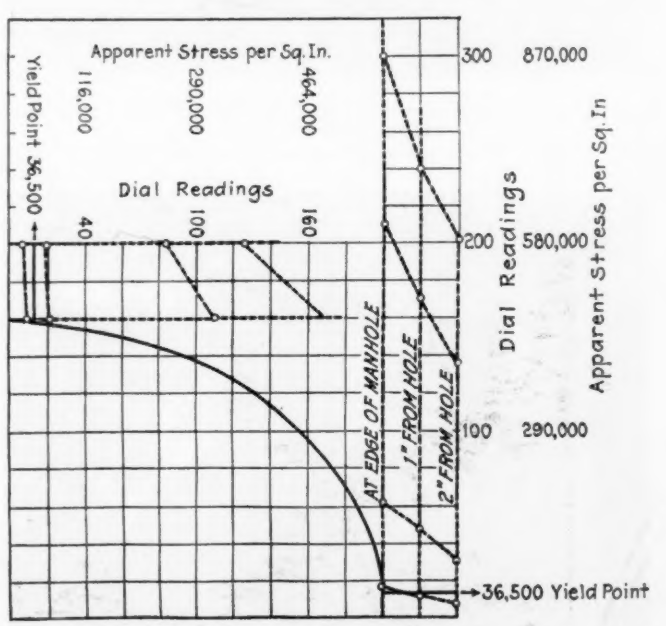


Fig. 2 Deformations Around Manhole of Tank

gage measurements being taken at all important points, this being the corporation's standard practice in the case of new designs.

The tank was first tested up to 900 lb., and it was found that the only permanent distortions that occurred were in the heads. On the solid head the only evidence of distortion was the formation of Luders' lines on the knuckle. On the head containing the manhole, however, even at 300 lb., the metal at the inside edge of the manhole stretched beyond the yield point, the apparent stress being about 46,500 lb. per sq. in. At 2 in. from the hole it was 23,200, which is still excessive.

Fig. 2 gives the strains in the various places, in divisions on the Ames dial used, each division equaling a stress of 2900 lb. per sq. in. The apparent stress figures are also given, though as there was permanent deformation, these figures are of course much greater than the actual stresses. The knuckle of this head also showed Luders' lines.

After 900 lb. had been reached, without any effect except as

[1] Union Carbide and Carbon Research Laboratories. Mem. A.S.M.E.

[2] It should be understood that the Power Boiler Code uses a factor of safety based on the ultimate strength of the plate used (in this case 5.5), but that the Pressure Vessel Code uses instead a maximum allowable working fiber stress of 10,000 lb. for plate less than 55,000 lb. tensile strength, and of 11,000 lb. for plate of 55,000 lb. tensile strength or over, so that the Pressure Vessel Code is not quite as strict as the Boiler Code, which provides that the minimum tensile strength of steel plate used in boilers shall be 55,000 lb. (Section S-9.)

mentioned, the pressure was released and the strain gage again applied at all points. No permanent set was found in any of the welds in the shell. There was, however, permanent set around the manhole opening. The pressure was again raised to 900 lb., another set of readings taken, and the pressure further increased after these readings to 1015 lb., in accordance with the schedule, readings also being taken at this pressure. On this second test no further increase of Luders' lines or other evidence of distortion was found on the solid head, but on the manhole head there was

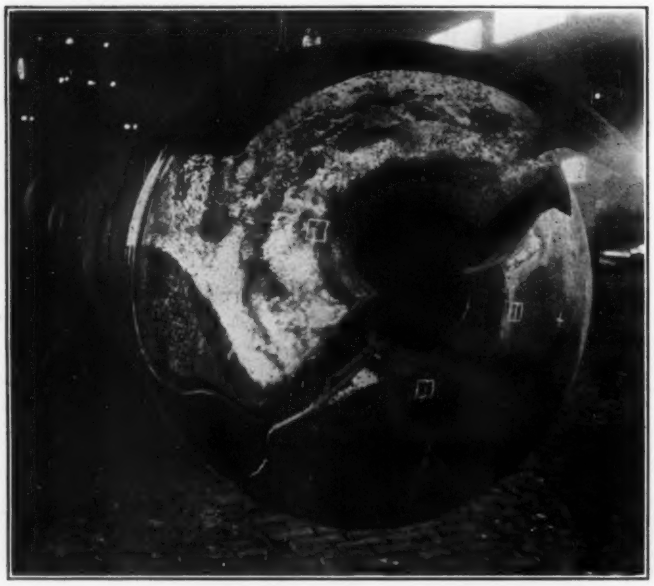


Fig. 3 Front View of Broken Head, Showing Location of Strain-Gage Measurements
(Note Luders' lines crossing each other on left side of head.)

Fig. 4 Side View of Fractured Head, Showing Failure in Metal 6 In. from Weld

further permanent set. The pressure was then released, another set of readings taken, and it was decided to make another test to see if the limit of yielding in the manhole head had been reached, as those making the test questioned the safety of the tank, and it was decided by them to carry the test to destruction unless it showed no further evidence of permanent set on the third test. At 930 lb. per sq. in. the head broke diagonally through the manhole as shown in Fig. 3.

It is well to have it understood clearly that there was no permanent set or excessive stress at or near any of the welds. The manhole head showed continually increasing distortion as the pressure increased at both the manhole opening and the knuckle. The solid head, though $^1/_8$ in. thinner than the manhole head, showed no sign of distress except at the knuckle, and that only on the first test.

It was noticeable after the break that the welds, manhole flange, and head had acted together, as there was no separation of the welds from the manhole or plate.

Several photographs of the tank are given showing the break (Figs. 3–5).

It should be mentioned that the data are not completely worked up yet, and that there may be necessary some minor change in the figures given, but they are close enough for the purpose for which this article is written, which is to point out the need of careful and complete study of stresses around openings in all pressure vessels.

The author suggests that boiler and tank manufacturers (and insurance companies covering these installations) take strain-gage readings on their products when completed, and at such other times after they have been put in service as may be possible, and the following procedure is suggested.

Drill the gage holes in the shop, and take readings at working

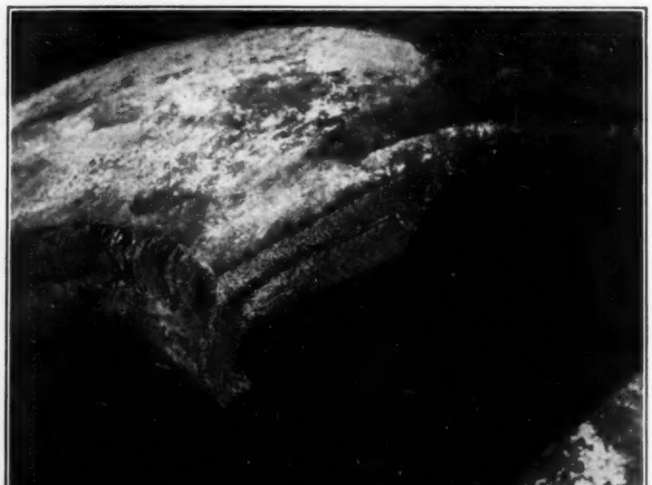


Fig. 5 Fracture Through Saddle Plate and Head
(Note that there is no separation between welds and plates.)

pressure and the test pressure while under test. At times of annual inspection have readings taken by those in charge of the vessels or by the insurance inspectors.

The schedule of the tank tests to be made jointly by the American Welding Society and the A.S.M.E. should include tanks made with various designs and locations of manholes, and these should be examined with special care.

In all these cases the stresses at the knuckles of the heads should also be measured wherever and whenever possible, as the formulas for these radii are apparently equally as arbitrary and incorrect as are those for manholes.

It is hoped that a more complete report will be given later, including all the data of the test and of the examination of the failed head.

Today the welding of sheet aluminum is a simple welding proposition and most any commodity can be manufactured from sheet aluminum and constructed so that oxyacetylene welding of same can be accomplished without any fear of failure in producing high class welds or of not being able to procure aluminum operators to meet with the required production.

Operators can be instructed very quickly in the use of this method of welding sheet aluminum and in most cases a young man or a young woman who has had a week or ten days' training can be placed on production work.—J. W. Meadowcroft in Journal of the American Welding Society, June, 1926, p. 49.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

ENGINEERING MATERIALS

Adhesives and Adhesive Action

An extensive investigation has been carried on since 1919 by various committees under the auspices of the British Department of Scientific and Industrial Research, and a second report on this investigation has now been published. The report is quite voluminous and only abstracts of certain parts can be given here. Great importance is attached to the work on the production of glue and gelatin from fish.

Toward the end of the war there was a serious shortage of glues suitable for aircraft construction, and the supply of land-animal raw material suitable for glue and gelatin making is limited. The fishing industry, moreover, has increased enormously with the introduction of steam trawlers, giving large supplies of skins and offal, which at present are not turned to complete account. Fish skins and other offal, other than bones, contain large quantities of gelatin, but their present value for technical purposes is small because of the impurities found with the gelatin. Some means was necessary for purifying the raw material before extraction of the glue, either by extracting the impurities without affecting the substances that yield the gelatin, or by making the impurities insoluble in hot water, so as not to pass into the extract. After prolonged experiment a process, now patented, was evolved for treating the stock successively by washing, maceration in very dilute alkali, further washing, maceration in very dilute acid (sulphurous or hydrochloric, according to circumstances), and final very thorough washing, the subsequent digestion being done at 60 deg. cent.

The fish glues prepared in these investigations were found to be almost as strong as the strongest available commercial glue when tested with dry heat, and stronger when tested by the wet-heat test. The process has the advantage of not leaving the residues after extraction unfit for conversion into fish meal. This is an important industry, which for economical reasons should be worked with the manufacture of fish glue. In addition to the purposes for which fish glues are already used, the odorless, tasteless, and not markedly hygroscopic glues prepared by this process can be used for woodwork, including furniture and veneers, paper boxes and cartons, and bookbinding. The gelatin can also be made colorless, and it is thought likely to serve for alimentary and photographic purposes at much below present market costs.

The longest section of the report, by Professor McBain and Dr. Hopkins, deals with adhesives and adhesive action. The general explanation of adhesive action is almost virgin soil, and the present work, though it gives ground for some tentative conclusions on the subject, may be regarded as preliminary. The general problem is submitted as involving at least two factors: the character of the bond between adhesive and surface, and the nature of the film of adhesive that transmits stress between its two surfaces without rupture. The investigation began with a series of pure qualitative experiments on the joints made by fifteen adhesives between a number of pairs of surfaces of different materials. These serve for the most part to suggest lines on which more exact experiment would be desirable, but a special series deserves attention, as throwing light on the manner in which the strength of joints is affected by surface porosity. In this series a joint was made with an adhesive between two smooth silver surfaces, under hand pressure, and after having been left to dry for four days, was found to be still moist and very weak. Similar results were obtained with silver plates, to each of which a piece of silver gauze was welded at several points. On substituting wood for one surface, and using a plain silver plate for the other, the joint dried in four days but was still very weak; the film adhered wholly to the wood where the joint was broken. A weak but somewhat stronger joint was obtained by using a gauze-covered plate, and a moderately strong joint by using two layers of gauze on the plate; when the joint was broken, the film in each of these joints adhered partly to the gauze and partly to the wood. It was thus evident that the wood had dried the film of adhesive, which had embedded itself in its pores. Though the conditions of experiment do not seem to exclude the possibility that, contrary to a suggestion in the report, adhesiveness set in with drying and thus contributed to forming the joint, it is clear that by the time a moderately strong joint had been formed the film had been embedded mechanically in the porous substance, and that the mechanical entanglement in the film of the pores of the wood contributed to the strength of the joint, and may have been wholly responsible for it.

Quantitative tests were made of the strength of joints on various materials, particular attention being directed to the determination of the strength of the joint rather than of the adhesive substance itself. Some of the results proved to be surprising; for example, the strength of the joints made with shellac cements between smooth metal surfaces was found in some cases to be as high as $2^1/_4$ tons per sq. in. in tension and shear. A variety of observations confirmed the belief that at least for this type of metal joint thin films of adhesive are much stronger than thick, as had already been shown with solder. An interesting example mentioned was that of joints made with a wax-free shellac, which was soft and quite pliable at room temperature; these joints made with an exceedingly thin film between nickel surfaces resisted a pull of nearly 4000 lb. per sq. in. Another general result to which the experiments seem to lead is that with most adhesives, better and more uniform results would probably be obtained if, as was done in many of these experiments, a thin film of adhesive was dried on the surfaces before the final adhesive film was applied, or perhaps even a triple gluing were used.

In no single instance did the adhesive fail to unite two surfaces, and the report suggests in general terms that any fluid which wets a non-porous surface and then by cooling or other process becomes a tenacious mass, may be regarded as an adhesive for that surface. (First part of report, abstracted through *Engineering*, vol. 121, no. 3152, June 11, 1926, pp. 700–701, 8 figs., *epA*)

FUELS AND FIRING

Industrial Fuels

In this paper, which deals mainly with utilization of gas as a fuel, the author, himself connected with one of the large western gas companies, states that in his opinion a private gas plant is in no way a necessity today except in special instances. The gas lines of the local gas company pass by the doors of most plants and are ready to supply all the gas which the factory needs at a lower cost and in a more reliable manner than is possible from privately operated plants. In the Middle West a super-gas system is being worked out which will be the largest in the world and will use the gas-generating facilities of Chicago as a center and will extend in a circle from Milwaukee, Wis., on the north, to Joliet, Ill., on the west, Kokomo and Terre Haute on the south, and Gary and Ft. Wayne, Ind., on the east. The combined gas-production capacity in this system is nearly 500,000,000 cu. ft. a day, exclusive of producer gas or blast-furnace gas.

In the discussion which followed A. E. Blake, Pittsburgh representative of the U. G. I. Contracting Co., stated that around Pittsburgh the conditions were different from those prevailing in Chicago, and that one of these conditions had been very troublesome for the manufacturer and combustion engineer. He referred to the natural-gas shortage and the necessity which had existed for the local gas companies to insist that their industrial consumers adopt some other fuel for winter use, or to be used as an auxiliary during the coldest days of the winter.

Manufacturers could not generally afford two separate sets of furnaces; hence the necessity for furnaces in which either oil or gas could be used as fuel. If designed for gas only, the volume of the furnace could be very considerably less than in the case where the furnace must also be able to do the required work with oil. But the furnaces must operate the year around, and it was not simply a question of additional cost of heat from the use of oil, or greater inconvenience at times when it must be used, but also of the steady loss of heat units at all other times from the increased size of the furnace, which made for additional losses through the greater area of wall, greater first cost due to this difference in size, and other disadvantages. It was due to this condition, Mr. Blake said, that many shops in this district were using oil throughout the year, and the gas companies were attempting by every means to get them to use natural gas during the summer months. (H. H. Clark, Industrial Gas Engineer, Peoples Gas Light & Coke Co., Chicago, in *Proceedings of the Engineers' Society of Western Pennsylvania*, vol. 42, no. 2, Mar., 1926, original paper pp. 100–108, 7 figs., discussion pp. 109–118, *g*. In the discussion special attention is called to a table on p. 117, giving a comparison of the properties of different kinds of gases.)

INTERNAL-COMBUSTION ENGINEERING

New Tendencies in Diesel-Engine Design

The author discusses various attempts, practically all of them previously published, in the direction of reducing the cost of operating Diesel engines as regards fuel, in particular the elimination of the compressor, the use of unconventional cycles, such as compounding, and attempts to burn solid fuels.

One of the methods of reducing the heat losses in a Diesel engine is by increasing the number of revolutions. Here, however, the piston side pressures increase and other difficulties arise. If double pistons and a single crankshaft are used the speed cannot be driven very high as difficulties with the upper piston arise. The author states in this connection that Junkers in his new airless-injection motor has not been able to use a speed higher than 500 r.p.m.

Another way of attaining higher economies lies in the direction of compounding. In the Bielefeld experimental compound Diesel engine the high-pressure piston runs at a speed eighteen times that of the low-pressure piston, whereby the losses to cooling water and exhaust are materially decreased. The compressions in the high-pressure end are also greatly increased. The higher the compression used, the closer are packed the oxygen molecules, which increases the intimacy of contact between the oxygen and injected fuel, and hence the velocity of combustion. The more rapidly combustion occurs the higher will be the temperatures and pressure and hence thermal efficiency. Furthermore, the more rapid the expansion of the hot and highly compressed combustion gases, the shorter the time of their contact with the walls and the smaller the heat losses through the walls to the cooling water. The gases in the comparatively slow-running low-pressure end of the motor, being of lower temperature and already partly expanded, do not lose as much heat as do gases in the case of single expansion in conventional motors.

As regards the pulverized-fuel motor, Rudolph Pawlikowski, formerly collaborator with Diesel, showed the author in May, 1925, indicator diagrams of such a motor, which would lead one to believe that excellent combustion took place. From German patents covering this motor, it would appear that dry powdered coal is delivered to the injector-air device and conveyed into a space not under pressure at the time. Thereafter the coal dust is injected into the motor by compressed air, proper devices being provided for regulating the amount injected.

The author refers briefly to some very unconventional types of motors; for example, one in which a crucible-graphite plate is used as the piston head. He believes also that it might be possible to insulate the piston against heat loss with Keramonit, which is an elastic material made of chrome-iridium wire netting and a ceramic mass, the material being of such a character that it can be made in thicknesses down to $^1/_2$ mm. (0.02 in.) and retain its strength up to temperatures of 1800 to 1900 deg. cent. (3272 to 3452 deg. fahr.). (First installment of a serial article by F. Ernst Bielefeld in *Schiffbau*, vol. 27, no. 11, June 2, 1926, pp. 313–316, 7 figs., *g*)

A Six-Cylinder Two-Stroke Oil Engine for Bus Service

The Maedler Engine Corporation, of Cleveland, Ohio is developing a power plant of the double-piston type designed to develop 125 hp. at 1200 r.p.m. The new engine, Fig. 1, has cylinders of $3^1/_2$ in. bore. In order to equalize the inertia forces on the upper and lower sets of reciprocating masses the strokes of the two pistons are made unequal, that of the upper one being $3^1/_4$ in., and that of the lower one, 4 in. The upper piston controls the intake and the lower the exhaust ports. This permits of the use of ports of exceptionally large area extending nearly all the way around the cylinder. The scavenging air enters the cylinder at the top, while the dead gases escape at the bottom. This location of ports makes it possible to obtain a high volumetric efficiency, which is further increased by offsetting the cranks for the upper and lower pistons in such a way that while the exhaust ports are opened earlier than the intake ports, the two sets of ports close at the same time. By using two pistons instead of a single one, the area of each piston

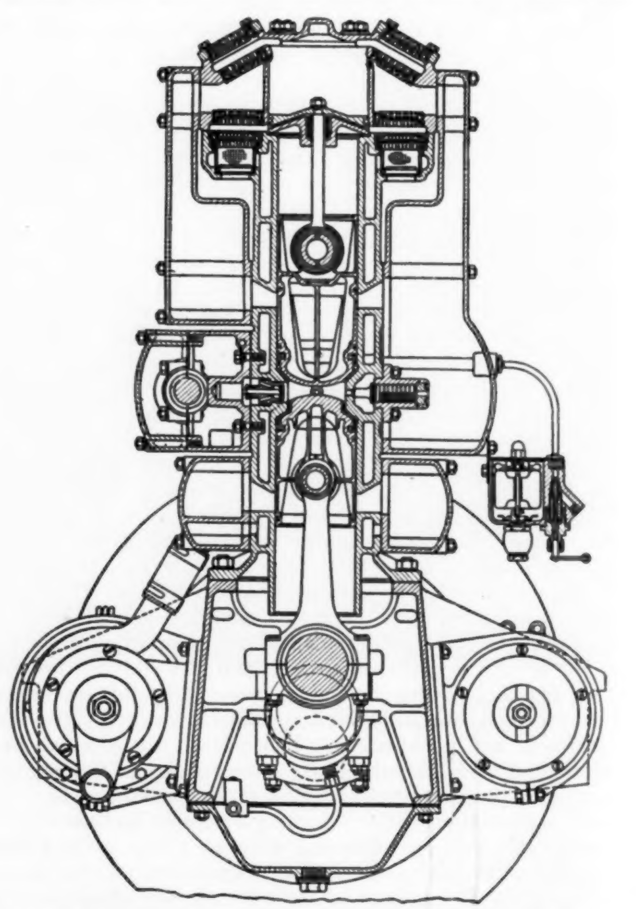


Fig. 1 Section Through One of the Cylinders of the 6-Cylinder 2-Stroke Maedler Oil Engine for Bus Service

head is decreased and the problem of properly cooling the pistons is made easier, making it possible also to obtain the high speed used in the present engine. The compression chamber is compact and none of its wall area is direct-water-cooled. The scavenging air is supplied by a double-acting air compressor mounted on top of each cylinder and operated from the wristpin of the upper piston. On the right-hand side is shown a safety valve which guards against any undue overloading of the engine by limiting the maximum combustion pressure to 600 lb. per sq. in. The cycle of the engine is as follows:

During the down stroke the lower piston uncovers the exhaust ports (which are arranged circumferentially around the whole cylinder bore near the lower end) at 60 deg. before lower dead center. The pressure in the cylinder now drops to atmospheric pressure, and 15 deg. later the air ports are opened by the upper piston. Scavenging air under 5 lb. per sq. in. pressure now rushes through these openings into the cylinder, pushing the remaining residual gases ahead of it out through the exhaust ports. Besides

thoroughly scavenging it, this operation fills the entire cylinder with clean air. Owing to the restriction in the center of the cylinder setting up a momentary pressure difference in the upper and lower halves, the so-called boring effect of the scavenging air is eliminated.

At 60 deg. past the lower dead center the exhaust and intake ports close, the desired timing being obtained by offsetting the crank throws controlling the movements of the upper and low pistons.

The fresh air charge is now compressed between the two pistons while they move toward the center of the cylinder. About 5 deg. ahead of the point at which the maximum compressions is reached, the fuel is injected into the hot and whirling air charge, and its combustion is very rapid. The time of fuel injection can be varied by the operator by mechanical means similar to those used for advance or retardation of the spark on electrically ignited engines.

Starting is accomplished by means of an air starter. When the engine is turning over the fuel supply is turned on, and the compression of 350 lb. is ample to ignite the first charge, even when the engine is cold. In fact, experiments have shown that regular firing could be obtained with 260 lb. compression. (P. M. Heldt in *Automotive Industries*, vol. 54, no. 24, June 17, 1926, pp. 1042–1044, 3 figs., *d*)

A Double-Acting Four-Stroke Marine Oil Engine

Successful demonstration trials of the new 4000-b.hp. double-acting oil engine which is shortly to be installed in the motor vessel *Stentor* took place in May, 1926. The engine is the first of its type to go into service and it will propel one of the most powerful single-screw ships afloat. It is of the Werkspoor type and has six cylinders $32\frac{1}{4} \times 59$ in. in diameter, with a service speed of 95 r.p.m.; it develops 5000 i.hp. at 92 r.p.m.

The following may be mentioned among the special features. A built-up crankshaft of the firm's patented Unity type is employed, and the top caps of the main bearing are held in position by nuts on the through-going staybolts. Each crosshead is guided by one ahead and two astern guides, sufficient space being provided between the guides to allow the top end of the connecting rod to be swung outward for dismantling.

The piston rods, which are 11 in. in diameter, are made of a special alloy steel. The forging is bored up the center with a $2\frac{1}{2}$-in. hole, which provides a passage for the piston cooling water. At the head of the piston rod is a large flange, to which the piston body is attached, this being the only joint. For attaching the pistons to the connecting rods, bolts of nickel-chrome steel are used, and special precautions are taken to guard against any fracture. The joint between the piston and its rod is a ground one and it is subjected to a water test of 1000 lb. per sq. in. Each piston has eleven rings, divided into two groups. A recess in the middle of the piston serves to take the heads of the piston bolts, and incidentally it also provides a ready means of gaging the tightness of the piston rings while the engine is working by the variation in pressure in this recess. If leakage occurs it generally takes place past the top series of rings, and in such a case the pressure on the piston-body recess will be increased. An automatic valve operated from the camshaft puts this recess into connection with a gage every time the piston recess passes an opening arranged at the side of the liner. Thus any rise in pressure can immediately be detected by the attendant.

An essential feature of the engine is the separate bottom combustion chamber which is attached to the side of the bottom cylinder cover. It is furnished with a ground face and carries the exhaust, inlet, fuel, and relief valves. The valves for the bottom and the top cylinders are interchangeable and may be easily and quickly removed when necessary. In the case of the bottom fuel valve a special compensating gear is fitted to the actuating motion so that the downward expansion of the main cylinder when heated is fully provided for.

It may be stated that for reasons of reliability and accessibility the offset type of lower combustion chamber is made use of, which means that the bottom side of the cylinder works at a lower power than does the top side. Maximum compression pressures of about 550 lb. per sq. in. on the top side of the piston and 400 lb. on the bottom side of the piston are of the order used.

The valve gear is such that in all positions of the gear except the last the bottom exhaust valves are held open and the bottom inlet valves shut and out of operation. By this means the hot exhaust gases from the top cylinders are utilized to warm up the bottom combustion spaces. Besides actuating the valve gear, as already described, the starting shaft controls the main starting valves in the usual way and also controls the fuel pumps and the fuel-injection air.

The engine is fitted with a separate fuel pump for each cylinder, which is double-acting, one end supplying the top cylinder and the other end the bottom cylinder fuel valve. Fuel delivery is regulated by controlling the lift of the suction valve in the standard way. (*The Engineer*, vol. 141, no. 3672, May 28, 1926, pp. 558–559, *d*)

MACHINE TOOLS

A Stern-Bush Boring Machine

It is not always convenient to withdraw the stern-tube liner of a vessel and remove it to the works for rebushing and boring, and, as an alternative, the liner is frequently rebushed in position The location of the stern tube in the frame renders it particularly difficult to rig up temporary boring gear, and in such circumstances the lignum-vitae strips are usually planed out by hand. The job, however, is a particularly awkward and tedious one. To speed up the work, and also to execute it more accurately, a boring machine has been introduced by Messrs. John W. Barnes, Ltd., Railway Works, Rock Ferry, Cheshire. The machine is normally designed for electric-motor drive, but can also be supplied for belt drive from any convenient source of power, such as a small gasoline or steam set. (*Engineering*, vol. 121, no. 3152, June 11, 1926, p. 692, illustrated, *d*)

MARINE ENGINEERING

The Rotor Vessel "Barbara"

The first vessel to be constructed from the beginning to be driven by Flettner wind rotors was launched at the yards of A. G. Weser in Bremen. She is a freighter with a deadweight capacity of 2800 tons, and is 295 ft. in length, 49 ft. 3 in. in beam, and 19 ft. deep. For general drive she is fitted with two six-cylinder four-cycle single-acting Diesel engines which run at 300 r.p.m. and their power is transmitted by a Vulcan hydromechanical gear drive to a single propeller running at 80 r.p.m. The engines are capable of generating 1000 b.hp. and of giving a speed of 10 knots.

The rotor drive embraces three cylindrical rotors, each with a height of 59 ft. and a diameter of about 13 ft. At their upper and lower ends they are provided with disks of a somewhat larger diameter than the rotor; by these disks the effect of the rotors is considerably increased. The rotors are built of a specially treated light metal. They are borne by an upper pivot on which they revolve and at the lower part there is a guide bearing which keeps them in position. The rotors are driven by electric motors, the power necessary for this purpose being generated by a small Diesel dynamo.

The vessel has been built for Messrs. Robert M. Sloman, Jr., of Hamburg, but the idea of building her was conceived by the German Admiralty, which takes a lively interest in the problem of rotor drive. In the *Barbara* the rotor drive is auxiliary, and will serve to increase the speed or to release the ship's Diesel engines from operation if there is sufficient wind. It is expected that there will be many occasions on which the ship will be able to run without using her propeller engines; the screw propeller will then be disengaged from the engines by the Vulcan gear and will revolve freely. If the wind is not sufficient to drive the ship alone but strong enough to give good additional power, only one main engine will run and the other will be disengaged. It is intended to make very careful investigations and trials with the *Barbara* under the supervision of experts in order to decide whether the rotor drive can be used with advantage for commercial shipping. The results of these investigations, which are being undertaken by the German Admiralty, will be published. (*The Times Trade and Engineering Supplement*, vol. 18, no. 412, May 29, 1926, p. 228, 1 fig., *d*)

The Maublanc-Lallie Marine Propeller

IT HAS been generally accepted among propeller engineers that the parts of the blade which give a maximum of efficiency consist of surfaces inclined at 45 deg. to the axis of the propeller. What the present inventors did was to make an effort to develop to the utmost the employment of surfaces inclined at 45 deg. and thereabouts. It is stated that in the ordinary propeller, because of the elliptical contour of the blade, the region within the angle of 45 deg. is comparatively little developed.

Because of the effort to develop surfaces having an angle of inclination of the order of 45 deg., the new propeller had to be given an unusual shape. In rotating it describes a truncated cone. It attacks the liquid with the thin edges of the blades, which latter gradually increase in width and thickness. The surfaces which are displaced near to the axis and ahead of the hub produce along the latter a very rapid flow of liquid, which inhibits cavitation. It has been observed that the wake with this propeller is very narrow,

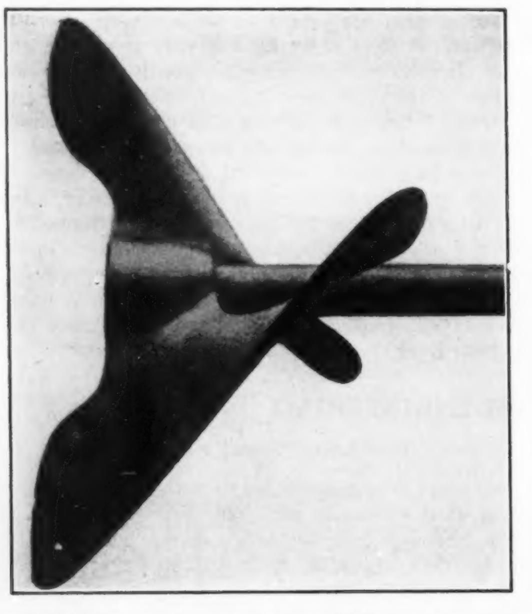


FIG. 2 TWO-BLADE MAUBLANC-LALLIÉ MARINE PROPELLER

which proves that the propulsive effort is exerted along the axis with a minimum of sidewise projection of the liquid.

The new propeller has been installed in and tested on several vessels previously equipped with conventional propellers, and it is said that the substitution has given most gratifying results. On the steamer *Saint-Brevin* the old propeller had four blades, 1.66 m. (65.3 in.) in diameter and was replaced by a Maublanc-Lallié three-blade propeller 1.54 m. (60.6 in.) in diameter. The 260-hp. triple-expansion engine ran the old propeller at 250 revolutions, while the new propeller at 212 revolutions gives the vessel the same speed as before. The reduction of revolutions means of course an economy in fuel oil and longer life of the engine.

In official tests of the gunboat *Tapageuse* (1300 hp. at 300 r.p.m.) made with a 1.94-m. (76.3 in.) three-blade propeller, the results showed a gain in speed over what was formerly obtained with a conventional propeller of the same diameter.

The efficiency of the propeller in reversing was shown to be particularly good. Running at full speed ahead the vessel was stopped within one length.

Moreover, it was found that with this propeller vibration is considerably reduced. This was discovered in tests with the 500-ton tugboat *Centaure* (634 hp.). With the conventional type of propeller this vessel shook in a distressing manner. When, however, the new propeller was installed, the vibrations were greatly reduced.

The proportions of the various parts of the propeller, shown in Fig. 2, cannot be determined in a general manner, and each unit has to be designed with due regard to its operating conditions. (W. Lallié in *La Nature*, no. 2721, May 29, 1926, pp. 351–352, 3 figs., *d*)

METALLURGY

The Heterogeneity of Steel Ingots

THE report of No. 5 Committee of the Iron and Steel Institute, appointed May, 1924, is an extensive document, and only a few of the points of special interest to mechanical engineers can be referred to here. The Committee was under the chairmanship of Dr. W. H. Hatfield, of the Brown-Firth Research Laboratories, and included prominent representatives of the larger British steel companies.

A knowledge of the degree of heterogeneity which is to be found in steel ingots of all kinds and of the manner in which it arises is of much interest, both from the technical as well as from the scientific point of view. For certain types of engineering projects developed during the last few years increasingly heavy ingots have been required and made, and the variations in the mechanical properties and chemical composition have sometimes proved disconcertingly wide. It has long been generally understood that as the mass of the ingot is increased, the heterogeneity becomes more accentuated, and one of the objects of the sub-committee has been to give a more quantitative expression to the degree of heterogeneity which may be reasonably expected. The evidence shows the composition to be of such an order that the facts should be made known, as they are of the utmost importance both to steel makers and to the users of ingots. The evidence presented is derived from the examination of a large number of ingots ranging from 15 cwt. to over 172 tons in weight. All of them may be regarded as reasonably representative of the type of ingot and the class of steel to which they belong when manufactured under good conditions.

It is sometimes considered that the heating of steel ingots and maintaining them at high temperatures for long periods of time, preparatory to forging and rolling, will, to a large extent, remove the heterogeneity, the idea being that prolonged heating brings about homogeneity by the diffusion of the elements segregated in the cast state. Such an opinion, however, requires considerable modification, in view of the fact that some of the larger examples studied display pronounced heterogeneity, notwithstanding that they have been reheated and bloomed prior to sampling for analysis, thus clearly indicating the degree to which heterogeneity exists after such prolonged heating of the ingot.

It may first of all be stated that no ingot ever produced is completely homogeneous, however carefully the steel may have been made and cast.

The following conclusions were arrived at. All ingots, no matter what their size, relative proportions, method of casting or processes of manufacture, show segregation of certain elements in well-defined zones. The degree of segregation is highest for the elements carbon, phosphorus, and sulphur, but is almost negligible for manganese and silicon.

A very important factor in the process of differential or selective freezing is the rate of cooling through the freezing range. If the cooling is rapid there is not the requisite time for the complete separation of the phases present in the metal just before freezing, and the less marked is the heterogeneity of the crystals.

This effect is of particular importance. First, in all ingots the outer layers pass through the freezing range very rapidly on account of the great absorption of heat by the mold, and there is not sufficient time for the phases to separate; hence the crystals of steel formed show little or no variation in composition; there is little segregation. As the rate of cooling falls, the time occupied in passing through the freezing range increases and the variations in composition become more marked; it is suggested that in the central zone, where presumably the rate of cooling is slowest, the separation of the phases is the most complete and the crystals show the lowest percentages of the segregating elements carbon and phosphorus.

Secondly, the cross-sectional area of the ingot has a fundamental bearing upon the process; the greater the diameter of the ingot the slower must be the rate of cooling of the interior portions, and therefore the more marked will be the differences of composition observable.

From such considerations it appears that even steel made under the most perfect conditions, perfectly free from extraneous material and of uniform composition when entering the mold, must exhibit, when solid, certain variations of composition because of this selec-

tive freezing. The degree to which these variations manifest themselves will increase: (1) As the carbon and phosphorus content of the steel increases; (2) as the rate of freezing of the ingot falls; and (3) as the cross-section of the ingot increases in dimensions.

The last portion to freeze in the top of the ingot must of necessity be richer in segregate of lower density and of lower melting point.

As regards the unsoundness along the central axis of the ingot and elsewhere, it is suggested that this is due to the meeting of, and loose cohesion between, the differently oriented systems of crystals growing from the walls and base of the mold. These planes and lines of weakness are associated with planes of segregation, which affords evidence in support of the general view as to the manner in which the heterogeneity comes into existence. If the crystals formed are purer than the mother liquor, and therefore leave a more impure liquid, i.e., segregate, on the plane of crystallization, then whenever two such planes meet there should be, as is indeed found, a collection of segregate. Further, the fact that the central axis is always a zone of looseness or weakness, seems to be direct evidence in favor of the progressive crystallization from the surface of the center of the ingot. Such a process would obviously leave a central zone of weakness, whereas if the crystallization were simultaneous throughout the central or free crystal zone, as is supposed by some, there is really no very apparent reason why there should be any central weakness. (*The Engineer*, vol. 141, no. 3671, May 21, 1926, pp. 528–530, *gA*)

In discussing this report J. P. E. C. Stromeyer hoped that engineers would not be over-alarmed at the results and conclusions arrived at in the paper. Engineers said that 0.06 per cent of phosphorus was a safe limit, but it had been demonstrated that there must exist areas in steel containing 0.6 per cent of phosphorus. He knew a case in which a shell plate of a boiler had stood for 32 years, and had then cracked. Upon analysis, a figure of 0.161 per cent of phosphorus had been obtained. He had recently come across another case, in which the shell plates of a water-tube boiler had cracked near the front end. The cracks did not extend to the rivet holes, and it appeared to be a case of segregation. He had not yet fully investigated the matter, but he had caused the faulty areas to be cut out. He thought the remaining portions would prove to be sound. He had investigated 47 cases of failure, and had been able to explain them all except 13, in which the material was very pure, i.e., low in phosphorus and nitrogen. The paper did not throw any light upon the effect of the presence of nitrogen in steel, but it did improve our knowledge of segregation. (Discussion of the Report on Heterogeneity of Steel Ingots, before the Iron and Steel Institute, abstracted through *Engineering*, vol. 121, no. 3152, June 11, 1926, pp. 685–687. Passage referred to above on p. 686, *g*)

MOTOR-CAR ENGINEERING (See Internal-Combustion Engineering: A Six-Cylinder 2-Stroke Oil-Engine for Bus Service)

PHYSICS

Flow of Gases at High Speeds

The author deals with the case of the flow of a gas from a vessel in which it is compressed through an orifice into the atmosphere or into a receiver at a lower pressure. He reviews the work of previous investigators such as St. Venant, Wantzel, and Osborne Reynolds, down to the experiments of Hartshorn, and points out uncertainties left in the work of the latter. The present investigation was undertaken to study experimentally the distribution of pressure and velocity in jets flowing through orifices of different forms, with special reference to the following points on which further evidence was believed to be necessary: (1) The existence of a minimum section of the jet and its variation in position and magnitude; (2) the relation between the pressure in the receiver and the pressure in the jet for increasing and constant rates of discharge; and (3) the possibility of the characteristics of high-speed jets being affected by the dimensions of the orifice and the viscosity of the air.

The paper is quite extensive and only some of the conclusions will be reported here. From observations of the pressure along the axis of the jet, axial distribution of pressure was determined from the position on the axis at which the theoretical critical pressure was reached. This position appears to depend on the shape of the orifice and, within limits, on the initial pressure of the jet. In the case of the diverging nozzle the position appears to coincide within the limits of accuracy of observations with that of the throat of the orifice, and is approximately independent of the initial pressure of the jet within the range of observations. In the case of the plain nozzle and the thin-lipped orifices the position at which the critical pressure is reached is in all cases appreciably downstream relative to the throats, this divergence appearing to diminish to a definite value as the ratio of p_r to p_0 (receiver pressure to initial pressure) is diminished.

As regards the radial distribution of pressure, it was found that the falling off in the value of the static pressure near the boundary is appreciable. Investigation was next made of the variation in the linear dimensions of the jet with distance from the throat of the orifice. It was found that:

1 In each of the three characteristic types of orifice which may be used for the discharge of gases from a vessel at constant pressure into a receiver at a pressure appreciably below the critical value $0.527\ p_0$, the section of the jet diminishes to a minimum value, at which the velocity is that of sound under the conditions existing, and then increases. This minimum section in the case of a free jet is not constant in area or position relative to the plane or throat of the orifice, but depends on the total ratio of expansion.

2 In a jet in which the expansion takes place within solid boundaries, i.e., a diverging nozzle, the minimum section may for all practical purposes be regarded as coincident with the throat of the nozzle for all ratios of expansion.

3 The flow of the fluid up to the minimum section is adiabatic in character.

Section 2 of the paper, dealing with the characteristics of the rate of discharge from orifices of different forms, cannot be abstracted here because of lack of space.

Section 3 is devoted to a consideration of the existence of a scale effect in the flow through geometrically similar nozzles. The tests appear to indicate that in order to obtain dynamical similarity of flow throughout the nozzles, the nozzles must be geometrically similar, a condition which it is thought can be ignored when the speed is in the neighborhood of the velocity of sound.

Part 2, on the characteristics of air jets at speeds above the velocity of sound, also cannot be abstracted because of lack of space.

The investigation on which this paper is based was carried out in the Engineering Department of the National Physical Laboratory. (T. E. Stanton, F. R. S., in *Proceedings of the Royal Society, Series A*, vol. 111, no. A 758, June 2, 1926, pp. 306–339, 14 figs., *eA*)

POWER-PLANT ENGINEERING (See also Railway Engineering: Railway Water Treatment)

1200-Lb. Unit of the Boston Edison Co.

The high-pressure unit installed at the Edgar Station of Edison Electric Illuminating Co. of Boston has been in operation for six months now and the following data are of interest in showing what may be expected of such a plant. It would appear there were some troubles, but surprisingly few, and such troubles as were encountered were not all attributable to high pressure. There was trouble due to vibration of the generator rotor, but this was taken care of by the use of a self-adjusting bearing. Since the installation of this bearing the unit has furnished 1600 hours of commercial service, including a run of over three weeks without a shutdown.

A carbon packing ring used in series with some labyrinth packings in the shaft packing broke, throwing the rotor badly out of balance and causing some damage to blading and stage packings. The packings were changed, however, and the new arrangement gave satisfactory results.

The blades of the first and second stage were found to be bent inward at the shroud end and the whole interior of the turbine-casing, diaphragms, and disks—was found to be lightly covered with a bright red deposit like iron oxide. Corrosion was found in evidence not only in the turbine but in the valves and piping and even in the boiler, the 350-lb. as well as the 1200-lb. units.

To quote from an editorial referring to the article here abstracted, "High pressure is 'selling itself' to the plant designer and operator. Costs and economies can be calculated and balanced, and in many

cases, for plants large or small, a definite and substantial saving can be demonstrated. Special and new operating troubles, we begin to realize, do not bar the way of progress toward the realization of these benefits, for, so far as present experience indicates, there are no operating troubles peculiar to high-pressure steam." (*Power*, vol. 63, no. 24, June 15, 1926, pp. 935–936, 3 figs., *d;* and editorial on pp. 937–938 of the same issue.)

Utilization of the Waste Heat of Boiler Installations by Preheating the Combustion Air

It is stated in this article that by preheating the combustion air, 70 per cent of the heat of the flue gases can be recovered. Efficiency curves are given for a modern water-tube boiler with an air preheater and economizer, and show that operating even with an overload, the efficiency does not drop greatly. The percentage of the air preheater in the total efficiency increases with increased boiler load.

The Schwabach preheater built by a German concern is equipped with a rotating heat accumulator. It consists, Fig. 3, of one or more vertical cylinders, the shafts of which are supported by ball bearings. Each cylinder is divided into two halves by a partition. One side is traversed by flue gases and the other (in counter current) by the air to be preheated. The gas streams are divided into thin layers by the numerous radial steel plates of the cylinder. Care is necessary in determining the proper cross-section. Both on the flue-gas and air sides the resistance is 5 to 8 mm. (1/5 to 1/3 in.) of water column, depending on the load of the equipment, consequently the power consumption for moving flue gas and air is very small. Strong local cooling is avoided wherever possible, as this leads to condensation, with consequent corrosion of the plates. The drive for each cylinder is accomplished by means of a hydraulic motor. This drive is designed to be very powerful and resistant and to produce a low angular velocity, so that the transmission of power to the air preheater cylinders is very simple. The operation of the air preheater requires as a result of the use of ball bearings only a few tenths of a horsepower. The pressure of an ordinary water supply of several atmospheres pressure is sufficient to operate the motor. The consumption of water is only 300 liters per hour, which cost only a few cents. Furthermore, the water leaving the motor can be used in ash removal. The air preheaters can be cleaned during operation, generally by blowing out. (Prof. Ernst Blau of Vienna, in an article translated by A. P. Sachs and published in *Combustion*, vol. 14, no. 6, June, 1926, pp. 374–377, 2 figs., *ge*)

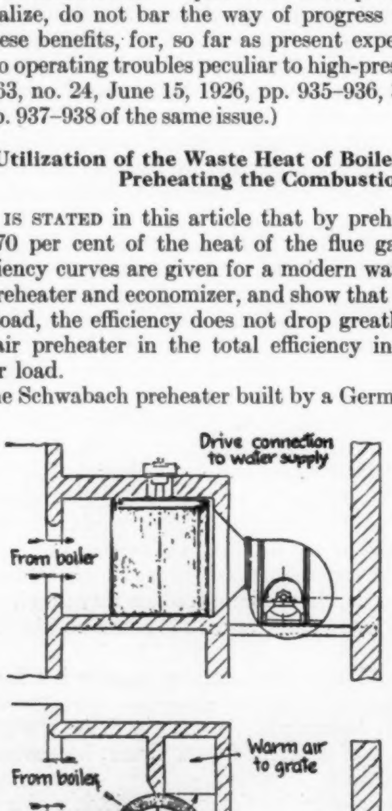


Fig. 3 Schwabach Air Preheater with Rotating Heat Accumulator

Central-Station Condenser Practice

Part of the National Electric Light Association Prime Movers Committee Report, showing present tendencies in condensing practice in power-plant operation.

Vertical condensers have been employed in one or two new plants, and undoubtedly their use will extend under conditions favoring this type of equipment. One member company reports several years' experience with vertical condensers with the water admitted at the bottom. In all new installations of this company the water will be admitted and discharged at the top, as this was found to give much better performance.

No material advantages seem to be gained in the radial-flow type condensers by the installation of steam lanes. The installations of the lanes in a condenser at the Gold Street Station did not noticeably improve the performance. At the Hudson Avenue Station, steam lanes have been omitted. Differential tube spacings, however, have been provided, the tubes at the bottom and center being closer together than those at the top and side, affording a constant frictional resistance.

It is felt that there can be no overwhelming advantage for a single-pass design as compared with the two-pass design, assuming that both are equally well worked out. Where a single pass is compared with a two-pass design, both the fixed charges and the operating costs of the circulating pumps should be considered. Where the tunnels are short and circulating water plentiful, a single-pass design will work out well; where the tunnels are long or where circulating water is restricted, the two-pass should show to better advantage than a single-pass condenser.

The majority of installations employ two circulating pumps per condenser, but a smaller number do not employ divided water boxes. Steam-jet air ejectors are employed for air extraction in the majority of installations tabulated, while in some instances both steam-jet and hydraulic pumps are provided. One plant employs an improved vertical reciprocating dry vacuum pump which possesses many advantages over the older horizontal type.

Condensate for oil coolers, inter-condensers, and air coolers is being abandoned by some, owing to operating difficulties outweighing possible gains. Reliability in operation, rather than economy, is sought. Where cooler water is desirable, the most economical supply is the circulating water. Failure of the hotwell pump or motor will not cause loss of vacuum, nor will the oil from the coolers reach an excessive temperature at light loads when the condensate is insufficient.

There is an increasing tendency to accomplish the deaeration of make-up and boiler feed in the condenser or the hotwell. Eleven of the 45 installations have deaerating hot wells, to which the make-up water is admitted at a temperature above that corresponding to the vacuum in the condenser. Tests made showed completed deaeration of make-up and boiler feed in the condenser or the hotwell. Eleven of the 45 installations have deaerating hot wells, to which the make-up water is admitted at a temperature above that corresponding to the vacuum in the condenser. Tests made showed completed deaeration, but every precaution must be taken to guard against contamination of the condensate with air after it leaves the condenser.

In comparing condenser performance from the standpoint of either air or circulating-water leakage, some engineers feel that the amounts should vary in some proportion to the size of the unit. While the quantity of air admitted with the steam varies with the quantity of steam condensed, it forms but a small percentage of the air to be handled. There is no more excuse for the leakage in a 50,000-sq. ft. condenser exceeding 5 cu. ft. per min. than in a much smaller condenser. The chief sources of leakage are at the flanges where the turbine and condenser are bolted together. Water-sealed glands of a turbine form the most perplexing source of leakage, existing on a great many more turbines than is realized. Air leakage may be kept at a minimum only through constant watchfulness.

Condenser tubes and tube failures received considerable attention, one member reporting the additional cost of No. 16 gage tubes being amply repaid by more satisfactory service and longer life than the standard No. 18 gage. Three different kinds of alloy were initially used in the tubes of the first three condensers at the Sherman Creek Station. Unit No. 1 was equipped with Bemal, the second with Admiralty alloy, and the third with 5 per cent aluminum-bronze tubes. All subsequent additions employed Admiralty-alloy tubing. This plant was placed in operation in the latter part of 1913 and, since that date, three condensers have been retubed, the fourth requires tubing, and from present condition, the fifth will require retubing this year.

A chart in the original article indicates the service-hours life for the various tubes which were installed. Aluminum bronze has

shown the shortest life. The Bemal bronze referred to above is an imported material. The original article also describes a counterweight lever support for condensers to compensate for the expansion and contraction. This has been developed for the Richmond Station of the Philadelphia Electric Company. (Report abstracted through *Power Plant Engineering*, vol. 30, no. 12, June 15, 1926, pp. 685–686, 3 figs., *gp*)

The Perry Air Preheater

In the Perry air preheater shown diagrammatically in Fig. 4 a large number of closely assembled corrugated sheets of metal are dipped into and out of the path of the waste gases.

The long and narrow elements are threaded on a rod and assembled in cages free to move vertically in their respective guides and chain-suspended over pulleys. The cages are balanced, and the power required for traversing them for any given length of stroke is centered only in ball bearings of the pulley shafting, and is negligible.

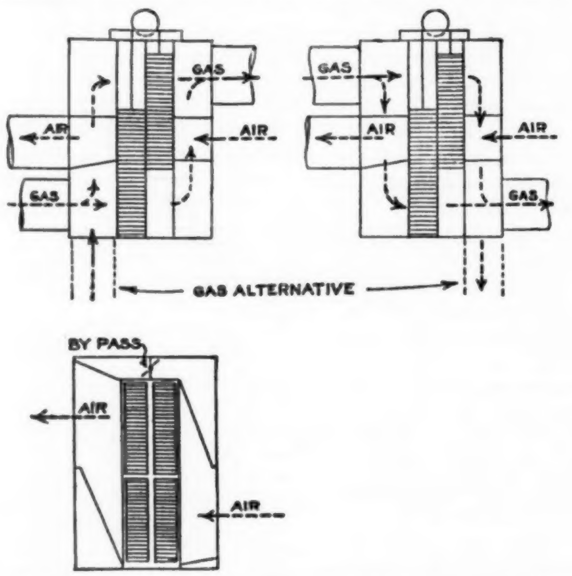


Fig. 4 Diagrammatic Arrangement of Perry Preheater Showing Paths of Circulation of Air and Gases

The moving parts are enclosed by an outer casing into which the gases enter, which may be either at the top, bottom, or side as desired. At the point of entry the volume splits up, one half passing through the upper portion of elements, and the other through the lower, thence reuniting (at reduced volume) at the point of exit on the opposite side of the casing. In order that the pressure loss ensuing shall remain constant in any position of the respective cages, simple forms of baffles are interposed which move into and out of action as required. The air to be heated moves in the countercurrent principle, and enters the casing by means of an internal duct, passing thence through both cages at all times, and leaves at the point of exit, which may be arranged at side or end of casing as required.

Sealing devices against undue leakage from gas to air compartments or vice versa are provided, and a simple form of multiple-jet soot blower is inserted in the air duct, the deposits being carried away by the forced-draft fan to the ashpit. The periods of operation of this accessory depend largely upon the class of fuel, the completeness of combustion, and the nature of the ash. The bypass damper is used at light load and overload, or in the event of excess of temperature. The general shape of the apparatus is oblong, thus satisfying the usually insistent demand for small ground space in most works. In all cases the width remains narrow at 5 ft. 6 in. up to 7 ft., while the height and length may be varied considerably to suit conditions.

It is claimed that under equal conditions of duty the Perry preheater is considerably less in weight and bulk than existing types of preheater or economizer, while for high duties the advantages, together with low cost, are increased.

As regards the type of air preheater which can be used with advantage when the waste gases are reduced, say, to 400–425 deg. fahr., it is stated that the immersion type of preheater is supposed to have advantages over the tubular or plate type since the weight and space occupied are considerably less and the heat-transmission factor higher. In the first case the heat must be transmitted through a wall of metal and layers of soot deposits, while in the latter both walls absorb the heat content of the gases and give up the heat when immersed in the air path. A coating of sooty deposit has not the same wasteful effect as in the case of the plate type. In fact, the effect is just the reverse, for its presence acts to some extent as a radiator of heat, and so long as the free gas paths are not unduly restricted the main principle holds good. (*Engineering and Boiler House Review*, vol. 39, no. 11, May, 1926, pp. 520–524, 2 figs., *d*)

The Future of the Steam Engine

In the editorial here considered, the belief is expressed that if steam-engine manufacturers would follow the lead of the automobile industry and other progressive industries there would be a different story to tell as to the future chances of the steam engine. It is said that not one of the old steam-engine builders maintains a department for intensive experiment and research along original lines, with the result that while practically every other type of prime mover is being intensively developed along every possible line, the old steam engine remains stationary in more ways than one. The following passage is quoted verbatim.

"Compare the modern automobile engine with the conventional steam engine of the same power output. A Chrysler '80' will develop a maximum of 90 hp. at 3000 r.p.m. with six $3^1/_2 \times 5$-in. cylinders, and it gets a power impulse only once every two revolutions. Furthermore, the whole unit could be set up in the same space required for a moderate-sized boiler-feed pump, and with little or no foundation.

"Add a piston rod, crosshead, and another cylinder head to this engine, give it a power impulse twice every revolution, which is four times as many as obtained in the automobile engine, and you would have four times the power output from this same unit or approximately 350 hp. Considering also the fact that the mean effective pressure of the steam engine under modern boiler pressures would also be considerably higher than that obtaining in the automobile engine, it would be quite possible to obtain approximately 400 hp. from a steam engine of this design, which, on account of the piston rod and crosshead, would not be over 50 per cent larger—and this only in height—than the unit we have taken for an illustration. Where does the present steam engine of the same power rating stand in comparison?

"Automobile statisticians point out that the cost of the engine of the average motor car is approximately one-fifth of the total cost of the car. The price of the Chrysler '80' ranges from approximately \$2700 to \$3700; assuming the high figure of \$3500 for the complete car, the cost of the engine alone would not be over \$700. Double this amount for adapting this engine to steam operation and you will have \$1400. This is less than \$4 per hp. Where does the conventional steam engine stand in this comparison, both as to cost and space requirements?

"The crying need today in the steam-power-plant field is for a power unit of small dimensions at a comparatively low first cost. Economy can in a great many cases be sacrificed for a lower first cost, although there is no reason why an engine of this type, operated with superheated steam, could not also be highly efficient; the temperatures, even with highly superheated steam, would not be any higher than those obtaining in the internal-combustion engine, and the lubrication problems would not be anywhere near as difficult.

"A power unit of this type, coupled with some of the latest developments in powdered-fuel boilers, or the recently developed single pass boilers, would create a radical change in the industrial-power-plant situation. Space requirements for the power units would be reduced to surprising proportions. Even the average dry-goods box that a great many architects set aside for the power plant in office buildings, hotels, and similar constructions, would be liberal for the units required. Excavations for heavy foundations would be practically eliminated. First costs and fixed charges would be cut to the bone, and as a consequence central-station service for a great many installations would be entirely out of the question, where under

the present conditions they are fully justified. Think it over, some of you manufacturers who are wondering what is going to happen to the steam engine, and your business, in the coming years." (Editorial in *National Engineer*, vol. 30, no. 6, June, 1926, pp. 259–260, *gc*)

Tests of a 60-Atmosphere-Pressure Steam Plant at the Borsig Works

As previously noted in Mechanical Engineering (vol. 46, no. 4, Apr., 1924, p. 219), a 60-atmosphere-pressure plant of the Schmidt type was installed at the locomotive works of the A. Borsig Co. in Berlin-Tegel some two years ago. The present article gives data of tests made on this plant for the purpose of determining the degree of utilization of fuel by the boiler plant, the ability of the plant to handle sudden peak demands, and the steam consumption and efficiency of a reciprocating steam engine working in connection with the new boiler.

As at present installed the boiler delivers the steam to a reciprocating steam engine exhausting at 10 atmos. pressure. This exhaust steam goes to steam hammers, of which quite a number are used in the plant, while the engine drives a large air compressor. As formerly live steam had to be generated to feed the hammers, a considerable economy from the new arrangement was expected.

The article describes how the boiler tests were made and gives full details of the test results obtained. These are reproduced here in Table 1 in condensed form. From the tests it would appear

TABLE 1 DATA OF TESTS OF 60-ATMOS.-PRESSURE BOILER PLANT (CONDENSED)

Water fed and evaporated, cu. m			58.12
Water fed and evaporated, kg			57,950
Average evaporation per hr., kg			9658
Average evaporation per hr. per sq. m. of heating surface, kg			34.5
Temperature of water fed to low-pressure pump, deg. cent			27
Temperature of water fed to high-pressure pump, deg. cent			97
Pressure in preheater boiler, atmos. abs			1.0
Pressure in high-pressure boiler, atmos. abs			59.9
Pressure at exit from superheater, atmos. abs			58.8
Steam temperature at exit from superheater:			
Measured by thermoelement, deg. cent			434
Measured by mercury thermometer, deg. cent			423
Superheat of steam corresponding to thermoelement measurement, deg. cent			161
Heat content of steam (Knoblauch tables), kg-cal. per kg			783
Heat supplied, kg-cal. per kg			756
Useful heat in steam, 1,000,000 kg-cal			43.8
Fuel: Upper heating value, kg-cal. per kg			7080
Lower heating value, kg-cal. per kg			6809
Fuel consumption, kg			7761
Average fuel consumption per hour, kg			1293
Grate load: kg. per sq. m. per hr			126.7
Grate load: kg-cal. per sq. m. per hr			896,000
Total heat consumption, 1,000,000 kg-cal			52.84
Water evaporated per kg. of fuel, kg			7.46
Steam generated at 100 deg. cent. from water at 0 deg. cent. (639.8 kg-cal.) per kg. of fuel, kg			8.82
Temperature of combustion air, deg. cent			26
Temperature of firebox, deg. cent			1370
Temperature of gases of combustion:			
At entrance to preheater, deg. cent			383
At extrance to flue, deg. cent			223
Heat losses:			
Heat carried away in flue gases, kg-cal. per kg			695
Heat lost through unconsumed gases, kg-cal. per kg			83
Heat lost through fuel residues on grate, kg-cal. per kg			158
Heat Balance:			
Heat supplied (lower heating value of fuel), per cent			100
Heat utilized:	Per cent		
Useful heat in steam		82.9	
Heat carried away in flue gases	10.2		
Heat lost in unburned gases	1.2		
Heat lost as fuel residues	2.3	13.7	
Varia loss		3.4	100

that the efficiency of the boiler plant in respect to utilization of fuel is 82.9 per cent referred to the lower heating value of the fuel, and 79.8 per cent when referred to upper heating value. As regards losses, the item of "varia" accounts for 3.4 per cent, which seems to be low in comparison with other tests. It would appear, however, that in these other tests the loss through unconsumed gases was not as correctly determined as it has been in the present series, in which a method was employed that gave precise measurements of the carbon monoxide and hydrogen present. In this method a tube filled with copper oxide was placed back of the usual Orsat apparatus and heated red hot. When the carbon dioxide and oxygen had been absorbed from the gases of combustion in the Orsat apparatus, the gases were conducted over the heated copper oxide. As a result of this the CO and H_2 combined with the oxygen of the copper oxide to form carbon dioxide and water. When the gas sample was cooled the reduction in volume due to condensation of the water and absorption of carbon dioxide indicated the content of the carbon monoxide and made it possible to compute the amount of hydrogen present.

A table in the original article indicates that out of the heat content in the fuel the high-pressure boiler consumed 62.3 per cent, the superheater 12.9 per cent, and the preheater 7.7 per cent. The coefficient of heat transfer in the feedwater preheater was found to be 14 kg-cal. per sq. m. per hr. per deg. cent. temperature difference. The fuel utilization of 83 per cent in the boiler plant seems to be a very good one. The steam output of 34.5 kg. per sq. m. per hr. may unquestionably be bettered, and, as a matter of fact, in tests carried on under the auspices of the Berlin Boiler Inspection Association, an evaporation of 38.5 kg. per sq. m. per hr. has been obtained. The boiler is taken care of by an ordinary fireman with the same certainty and ease with which boilers are handled at ordinary pressures. The only difference is in the manometer, which reads 60 atmos. instead of 20.

From the fact that the boiler has operated day in and day out with ordinary firing in excess of 2500 hr. without any trouble developing, as well as from other observations, it would appear that the Schmidt-Borsig boiler provides a fully satisfactory solution of the problem of high-pressure steam generation.

In order to determine whether the boiler would be capable of handling unusual conditions, in particular variations in load, two tests were carried out, in one of which the feedwater pump was stopped and in the other the pressure was permitted to drop materially. The original article gives details as to how these tests were carried out.

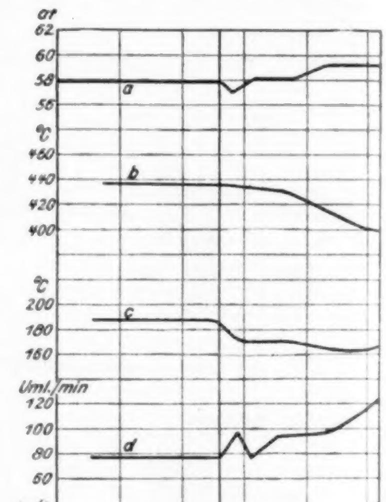


Fig. 5 Behavior of High-Pressure Boiler with the Feedwater Pump Stopped

(*At* = atmos. pressure; *uml/min.* = revolutions per min.; *kg/h.* = kg. per hr.; *a* = boiler pressure; *b* = steam temperature at exit from superheater; *c* = flue-gas temperature; *d* = r.p.m. of steam engine; *e* = steam output of boiler; *f* = weight of condensate; *g* = measurement with diaphragm orifice.)

In the test with the feedwater pump cut out, water was first supplied until the glass showed a high water level, after which the supply was maintained long enough for the boiler to come to regular operating conditions. This is indicated in Fig. 5 by the line *e*. At 5:08 the feedwater pump was cut out, and in order to maintain the steam pressure as even as possible the number of revolutions of the high-pressure reciprocating steam engine were increased (line *d*, Fig. 5). The increase in steam generation kept on until the close of the test at 5:21, i.e., until the level of the water in the boiler reached the lowermost mark. The greater steam delivery due to the increase in r.p.m. of the engine shows in the weight of condensate (line *f*) and also in the measurements with a diaphragm orifice (line *g*). As a result of the increased steam delivery the temperature of superheat fell off, as did also the temperature of the exhaust gases because of the increased heat transfer to the superheater. From this it would appear that, assuming that water was first in the boiler at the high level, it is perfectly possible to increase the steam delivery from the boiler by cutting out the feedwater pump. This is of course due to the fact that the heat utilized under normal conditions to raise the temperature of the feedwater is employed for steam generation when the feedwater supply is cut off.

The next test was made with the feedwater pump running, but with the pressure in the boiler permitted to drop. In this test the water level was first brought to its normal position, the steam pressure in the boiler held at 57.8 atmos., and the whole unit then permitted to come to a settled state of operation under ordinary feedwater supply (Fig. 6, lines *a* to *e*). At 7:04 the steam delivery from the boiler was increased by increasing the engine r.p.m., while the amount of fuel on the grate was maintained as steady as possible. As a result of this the steam pressure fell off, which brought about increased steam generation. The number of revolutions of the duplex feedwater pump gradually began to rise,

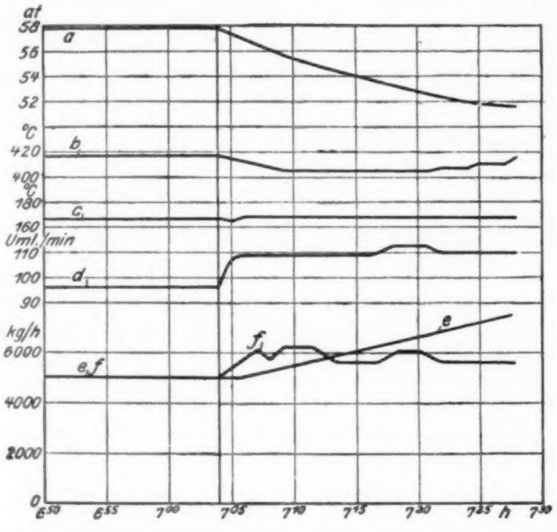


Fig. 6 Behavior of High-Pressure Boiler When Demand of Steam Is so Great as to Reduce Pressure

(*At* = atmos. pressure; *uml/min.* = revolutions per min.; *kg./h.* = kg. per hr.; *a* = boiler pressure; *b* = steam temperature at exit from superheater; *c* = flue-gas temperature; *d* = r.p.m. of steam engine; *e* = feedwater supplied; *f* = steam output of boiler.)

because this pump was fed with steam at a constant pressure of 15 atmos., but was enabled to increase its output (line *e*, Fig. 6) because of the fall of pressure in the 60-atmos. boiler against which the pump was working.

The increased steam delivery to the engine is indicated in Fig. 6 by the increase in weight of condensate and the diaphragm orifice reading. Since the number of revolutions of the steam engine was held practically uniform at its new higher value, the boiler output was also approximately uniform (lines *d* and *f*, Fig. 6). The superheater temperature decreased as the steam output increased and then remained approximately uniform, whole the flue-gas temperature did not change at all (lines *b* and *c*, Fig. 6). The test was completed at 7:27, after 23 min. of running, with the pressure dropping gradually to 51.6 atmos., and showed that in that length of time the steam output would be raised from an average rate of 5000 kg. (11,000 lb.) per hr. to one of 5800 kg. (12,760 lb.) per hr.

From the foregoing it would appear that in the case of a high-pressure boiler of the type under consideration here considerable peak loads may be handled for a time either by cutting off the feedwater pump (provided a high water level has been previously established in the boiler) or by permitting the steam pressure to drop. These two methods can be practiced singly or together, and in this way the boiler may be made to deliver exceptionally large amounts of steam without increasing the amount of fuel burned on the grates. The latter can be done, however, when conditions are suitable. All of which would indicate that the boiler is quite as flexible in its output as boilers of lower pressure.

In order to test the economy of such a high-pressure installation the following comparison may be instituted, assuming a steam forge shop that uses 6300 kg. (13,860 lb.) of steam per hr. at 10 atmos. pressure, and also such a machine as, for example, an air compressor that requires 760 hp. for its operation. The old boiler plant operating at 16 atmos. pressure was found to be unable to handle the situation.

Table 2 compares the plant operating at 60 atmos. pressure with one operating at 16 atmos. condensing and delivering steam to the hammers by throttling live steam from the boiler. In the case of the 60-atmos.-pressure unit the total consumption is 6400 kg. per hr., while in the other case it is 9850 kg. per hr. The heat consumption of the feedwater pump was determined from the power requirements of an electrically driven centrifugal pump, the necessary electrical energy being generated in the 16-atmos.-pressure unit. The initial costs given in Table 2 have been communicated to the author by the A. Borsig Co., and the table would indicate that at 2400 hr. of operation per year and with coal costing 25 marks ($6.20) per metric ton (2200 lb.) there is a saving in favor of the high-pressure installation of 24,500 marks per year, against which there is a greater first cost of 35,000 marks. It would therefore appear that the excess in cost would be paid for by savings in a year and a half, and that, taking it all around, the 60-atmos.-pressure installation is the more economical. (Prof. E. Josse, Charlottenburg, in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 70, no. 21, pp. 677–684, 11 figs., *eA*)

TABLE 2 COMPARATIVE FIGURES INDICATING RELATIVE ECONOMY OF THE HIGH-PRESSURE PLANT AND 16-ATMOS.-PRESSURE PLANT, BOTH OPERATING AN AIR COMPRESSOR AND STEAM HAMMERS

Consumption of steam at 10 atmos. pressure for steam hammers, kg. per hr.		6,300
Power consumption of air compressor equivalent to effective output of steam engine, effective hp.		760
Indicated output of steam engine, assuming 90 per cent mechanical efficiency, i.hp.		844
Boiler efficiency, per cent		80
Boiler pressure, gage, atmospheres	16	60
Steam consumption of steam engine, kg. per i.hp. per hr.	4.2	7.59
Heat consumption of steam engine, kg-cal. per i.hp. per hr.	4.2 × 715 = 3,000	7.59 × 85.7 = 650
Heat consumption of auxiliary condensing engine (only in low-pressure plant), kg-cal. per i.hp. per hr.	0.025 × 3,000 = 75	......
Heat losses in piping, kg-cal. per i.hp. per hr.	4.2 × 8 = 34	7.59 × 5 = 38
Pump output of feedwater pump, i.hp.	5.9	14.2
Heat consumption of feedwater pump, kg-cal. per i.hp. per hr.	58	138
Total, kg-cal. per i.hp. per hr.	3,167	826
Heat consumption considering efficiency of boiler and adding 12 per cent for losses in raising steam, fuel losses in ashes, etc., kg-cal. per i.hp. per hr.	4,440	1,156
Saving in heat, kg-cal. per i.hp. per hr.		3,284
Saving in coal, assuming lower heating value = 6800 kg-cal. per kg., kg. per i.hp. per hr.		0.483
Saving in cost of coal per annum, assuming 300 days of 8 hr. and coal at 25 marks per metric ton, marks		**24,500**
First Cost:		
1 Water-tube boiler for 16 atmos. pressure, 350 sq. m. area, including traveling grate, superheater, preheater, brickwork and installation, marks	105,000	
1 Single-pass boiler for 60 atmos. pressure, 100 sq. m. heating surface, 285 sq. m. preheating surface, complete, marks		130,000
1 760-effective-hp. steam engine, conventional design for 16 atmos. pressure, with jet condenser, including installation, marks	71,000	
1 760-effective-hp. counterpressure steam engine working at 60 atmos., including installation, marks		51,000
Feedwater-supply devices, piping, including insulation and installation, marks	20,000	40,000
1 Accumulator boiler for 10 atmos. pressure between 60-atmos.-pressure steam engine and steam hammers, marks		10,000
Total first costs, marks	196,000	231,000
Excess cost for the high-pressure plant, marks		**35,000**

RAILROAD ENGINEERING

Pitting and Correction in Locomotive Boilers

The *Railway Review* announced some time ago (compare Mechanical Engineering, vol. 48, no. 2, February, 1926, p. 167) a prize of $1000 for the best paper on Causes of Pitting and Corrosion in Locomotive Boilers This prize was won by Wm. M. Barr, consulting chemist of the Union Pacific System.

The conclusions to which the author comes are that the presence of oxygen itself in the boiler water increases corrosion, the latter being controlled by the concentration of hydrogen ions. From the nature of the corrosive process, the more homogeneous the material the less susceptible it will be to attack of the elements.

It is well known that steel is not a perfectly homogeneous material, and owing to this fact different points on a boiler tube will show a difference in electrical potential, so that with water in the boiler containing any salts which are good electrolytes a current will flow through this electrolyte from one point to the other, with a consequent loss of metal

from the positive pole. A continuance of this process develops a pit in the metal.

The author therefore recommends a very careful selection of materials, and is particularly in favor of hot-rolled-steel boiler tubes, as in this process the metal, being worked hot, is not subjected to so severe a strain, and when properly cooled the crystalline structure of the metal is likely to be more uniform.

The use of charcoal-iron tubes has long been established, and this metal, on account of its uniform character, has many desirable properties. However, the problem of working it in the flue sheet makes it necessary either to weld the material into the sheet or to put steel safe ends on the tubes, because steel is the most satisfactory of all metals from the boilermaker's standpoint. The welding of flues in the sheets is now being practiced in many places, both on steel and iron tubes.

A number of alloy steels have been proposed as being especially resistant to corrosion. The use of such tubes, however, is as yet in the experimental stage, and whether or not it is more profitable to pay the higher price for special steel alloys or to use the best quality of standard steel tubing, has not yet been demonstrated. The author now has a series of tests being carried out along this line.

The author also makes the following recommendations:

In handling water treatment, remove incrusting matter, and carry an excess of caustic soda as far as operating conditions will permit, up to five or six grains per gallon if possible.

Maintain low concentration of dissolved salts in the boiler water by systematic use of the blow-off and frequent washing or changing of water, using hot-water washout plants.

Remove oxygen and other dissolved gases from the water as far as possible. The open feedwater heater, while thus far inadequate, is the best means at hand, and improvement will doubtless be made in this class of equipment.

Last and most important of all, provide for competent supervision of water treatment and the use of water in locomotives by having a thoroughly trained and responsible officer in charge of this work with an adequate staff to handle all phases of the problem. Such an officer must have the fullest coöperation of the mechanical and operating departments of the railroad.

The policy here outlined has resulted in a pronounced reduction in corrosion and pitting, and may rightfully be expected to produce constantly improved conditions, and pay substantial dividends on the investment. (Wm. M. Barr in *Railway Review*, vol. 78, no. 23, June 5, 1926, pp. 977–983, 13 figs., *gp*)

Three-Cylinder Engine with McClellon-Type Water-Tube Boiler on the N.Y., N.H. & H. R.R.

The American Locomotive Company recently delivered to the New York, New Haven & Hartford R.R. three Mountain-type engines unique in that they represent the first application of the McClellon-type water-tube boilers to three-cylinder locomotives. The McClellon-type boiler was described in Mechanical Engineering, vol. 48, no. 4, April, 1926, p. 376. In the present instance, however, certain modifications were introduced. One of these modifications was to increase the boiler pressure to 250 lb., which, with the use of a 70 per cent limited cut-off, promised improvements in steam economy. These features and others were incorporated in engine No. 3550 (referred to in the original article as 3500).

This engine was tested in runs between New Haven and Providence, a distance of 113 miles, in comparison with one of the standard engines of the road, No. 3324. A comparison of the outstanding items in the performance of the two engines taken from the summary of the test data indicates that the new engine hauled 3.2 per cent more tonnage than 3324, maintaining the same average speed and the same running time over the district, and working at 16.5 per cent shorter cut-off. This resulted in a saving of 10.7 per cent in coal, or a decrease of 15.1 per cent in the amount of fuel consumed per 1000 gross ton-miles.

Because of the use of higher boiler pressure and the limited cut-off by engine 3500, a saving of 5 per cent in pounds of water per dynamometer horsepower was effected, which, coupled with a 12 per cent increase in evaporation per pound of dry coal, resulted in a decrease of 18 per cent in dry coal per dynamometer horsepower-hour. The McClellon boiler of engine 3500 showed an increased efficiency of 9.4 per cent over the standard boiler of engine 3324, while there was an increase in overall thermal efficiency of 15.5 per cent in favor of the McClellon boiler.

On the Mountain-type engines the boilers are $79^5/_8$ in. inside diameter at the front end and 93 in. outside diameter at the throat. They were designed for a working steam pressure of 265 lb. with a factor of safety of 4.25. The horizontal barrel seams on the first (conical) and the second (straight) courses are decuple riveted, butt- and double-strap construction, welded 15 in. front and back. The third course extends beyond the back tube sheet at the front throat connection, this extension becoming a dry shell, riveted at the top to the outside drums. At the junction of the dry-shell riveting to the drums and the back-tube-sheet riveting the third course is cut away to allow for calking the third course to the back tube sheet, this cut-out being enclosed afterward by a cast-steel cover plate. Where the back-tube-sheet flanges for the drums come into contact with the flattened corners of the drums, the triangle thus formed is filled by welding from both sides. Due to the flange of the back tube sheet extending inside the water space of the boiler, and with no provisions made for calking, the entire circumference of the back tube sheet is welded to the third course, on the combustion-chamber side. The throat section is formed of two shells stayed with rigid staybolts, and its upper ends are riveted to the dry shell, while the outside ends are fitted with caps. Handholes were applied opposite each connection of the firebox ring, with metallic gaskets having asbestos inserts. The circulating trough applied below the third course and ahead of the throat is stayed by transverse hollow staybolts, by vertical reduced-body staybolts, and by longitudinal stay rods. The drums are flattened at adjacent sides for their attachment together by 1-in. screw rivets, and they are single-riveted to the back tube sheet.

The 4-in.-diameter tubes are swaged at their upper and lower ends to 3 in. in diameter. They are staggered and bent to templets so as to enter the drums perpendicularly on the radius, and the upper ends are rolled and headed in the drums, while the lower ends are rolled and flared into the firebox ring. The combustion-chamber tubes are 4 in. in diameter, with their upper ends swaged to 3 in. where they are rolled and headed into the drums. (*Railway Review*, vol. 78, no. 24, June 12, 1926, pp. 1061–1066, illustrated, *d*)

Designing Locomotives to Reduce Rail Stresses

Data of tests carried out under the auspices of the A.R.A. and A.R.E.A. on rail stresses and their bearing on the design of locomotives. The stresses were chiefly carried out by means of an apparatus known as the stremmatograph, by means of which the strain is recorded at various places on the rail. Each of the instruments carries two disks, each disk recording data for four runs and each run producing from 22 to 30 stress indications. The number of readings that must be taken for the proper reduction and analysis of data is therefore enormous, and, for example, it is stated that the reduction of data collected in a single season by the special committee of the two associations required 470,000 individual stress readings.

Insufficient counterbalance, particularly in the main driving wheels, was found to be the cause of the most severe stresses produced in the rails of straight track, and interesting information was obtained both on the condition of counterbalancing and the action of the lack thereof. Among other things, it was shown that at high speeds the stresses under the main wheels of the engine were greater when the crankpin was down than when the counterweight was down.

As a remedy for this condition it was found necessary to keep the centers of gravity of these parts as close as possible to the planes in which the counterweights revolve.

As a step in the development of a more satisfactory counterbalance for the heavy Santa Fe type locomotives, an engine of this type included in a recent order for new locomotives was equipped with a special arrangement of counterbalance. The main wheels of this locomotive were cross-counterbalanced to compensate for the differences in plane of the rotating masses. The reciprocating weights of this locomotive are counterbalanced independently of the revolving weights by the use of small weights applied at right angles to the counterweights in each driving wheel other than main. These small weights are applied to the wheels on the opposite side

of the engine from the reciprocating parts whose weights they are intended to counterbalance. This locomotive, when tested, showed that the counterbalance effect of the main wheels had been practically eliminated, while the counterbalance effects of the other wheels were quite low at all speeds. The engine has now been in service for a period of nearly two years and has proved to possess very good riding qualities, as well as remarkably low track-stress characteristics.

Further investigation has shown that speed effects are of relatively minor importance in the consideration of rail stresses produced on curved tracks. Interesting data were also obtained by running the Mountain and Santa Fe type locomotives into the 10-deg. curve of the test track and allowing them to come to rest without the application of brakes. The relative positions of the various wheels and lateral deflections of the heads of the rails from no-load position were determined. These and other tests gave valuable information as to the possible changes of construction or adjustments of parts of a locomotive which affect the tracking of the different pairs of wheels or the position assumed by the rigid wheelbase with respect to the rails. It has been found that this has the effect of changing the so-called pivot point and therefore affects the rail stresses produced, particularly the characteristic slow-speed stress in the inside rail under the next-to-rear driver.

The Santa Fe type locomotive, as originally built, was equipped with plain tires on the main or middle pair of driving wheels, and these locomotives developed in the inside rail of the 10-deg. curve, under the next-to-rear drivers, stresses amounting to approximately 50,000 to 55,000 lb. per sq. in. On account of the serious magnitude of this stress, a series of tests were made to determine the effects of using plain tires on other pairs and combinations of driving wheels. On one of the test locomotives, the plain tires were shifted from the main or third pair of drivers to the fourth, or next-to-rear pair, the main wheels being equipped with flanged tires for this test. This change in location of the plain tires had the effect of transferring the high stress in the inside rail from the fourth driver to the main drivers and increased it to 65,000 lb. per sq. in., which approximates the elastic limit of rail steel. Later tests were made with both the third and fourth pairs of drivers. The effect of both of these latter arrangements was to transfer the heavy stress in the inside rail of the 10-deg. curve to the rear driver with no reduction in the magnitude of the stress. The tests showed plainly that the use of flangeless tires has the effect of increasing rather than decreasing the stresses produced by long-wheelbase locomotives in the inside rail of superelevated curves.

The results obtained in these tests made it possible to recommend distributions of weights for the Mountain, Mikado, and Santa Fe types of locomotives (given in the original article) and indicates that with this information it would be possible to build new locomotives of these types with considerably heavier driver loads without unduly stressing existing tracks.

The investigation also resulted in the development of a practical four-wheel trailer truck that may be applied in place of the usual two-wheel truck. While at present it is not found necessary to utilize this type of truck, it seems probable that it will come into more general use with the constantly increasing demands for greater tractive power and utilization of poorer grades of fuel, which will, without doubt, necessitate larger and heavier fireboxes and grates. (Paper by H. H. Lanning, M.E., A.T. & S.F. Ry. Co., in *Proceedings of the New England Railroad Club*, Apr. 13, 1926, original article pp. 78–93 and discussion pp. 94–101, *eA*)

A Forecast of the Probable Future Development of Railway Water Treatment

In the estimation of the author, railroads have passed through the period of pioneer development in the treatment of locomotive water supplied and are now approaching an era of refinement that will undoubtedly lead to still greater development. As far as the railroads are concerned, water treatment has not only been an economic necessity but in many cases it has been an actual operating necessity. The value of water treatment has become so well established through records of savings in boiler repairs, fuel economy, and the reduction of engine failures, that it is becoming apparent that treatment must be extended to include waters of so-called "fair" quality. As a matter of fact, it is stated that water that was considered fair a few years ago has become the bad water of today.

One of the problems that will receive more attention in the future than it has in the past is the removal of mud or other suspended matter from railroad water supplies.

The rivers of the Middle West carry an average of from one to one and a half pounds of suspended matter per thousand gallons of water throughout the year, with a maximum of 5 or 6 lb. during the freshet seasons, while the southern and some of the western streams carry still more. The objection to the presence of mud or other suspended matter in boiler waters is not altogether due to the necessity for frequent washing of boilers to prevent foaming and possible mud burning of sheets due to the use of turbid water, but also to the fact that the mud is deposited on the tubes and sheets, and in the presence of dissolved solids helps to form scale.

Another possible future development of water treatment is the more extensive use of filters. It is commonly accepted that the temporary hardness remaining in water after being softened with lime and soda ash is materially lowered by filtration through sand. Where filters are used in conjunction with lime and soda-ash softeners, no other coagulant is required as a general rule. Improvements in the design of water-treating plants will no doubt include a more efficient type of treating tank, particularly in regard to sludge removal. None of the present systems is entirely satisfactory, for they do not completely remove the sludge and are extremely wasteful of water, and the sludge nearest the outlet is the first to be picked up, while two-thirds of the openings are usually discharging clear water before the sludge at the outer edge of the tank is disturbed.

As regards zeolite water softeners, the author states that the chief concern regarding the use of zeolite is on account of the possibility of increased foaming due to the conversion of the various elements in the untreated water to sodium compounds in the treated water, which is characteristic of zeolite treatment. It is claimed that the foaming may be minimized with the exclusive use of zeolite-treated water, which is practically free from suspended matter. This is not always possible on a railroad unless entire engine districts are equipped with zeolite treatment. Another factor which has reacted against their use for railroad supplies is the fact that with certain waters pretreatment is necessary. For example, if the water contains an appreciable quantity of iron it must be pretreated before passing through the zeolite softener, or if the water is turbid it must be filtered before it can be handled successfully. With the lime and soda-ash plant no prefiltration of the water is required, as sand filtration after reaction and sedimentation is provided in all modern equipment.

A possible solution of the problem is a combination lime-soda-zeolite plant with pretreatment by lime and soda ash for the removal of the bicarbonate of lime and magnesia, iron, and free carbon dioxide, the neutralization of sulphates and the reduction or organic matter, silica and alumina, followed by the zeolite treatment to produce a water of zero hardness with a minimum of suspended matter. If this type of plant can be developed successfully and economically it is not at all unlikely that zeolite treatment will be further extended in the handling of locomotive feedwater. (C. R. Knowles, Mem. A.S.M.E., Supt. Water Service, Illinois Central System, in a paper before the American Water Works Association, Buffalo, N. Y., June 9, 1926, delivered under the auspices of the Committee on Boiler Feedwater Studies. Abstracted through *Railway Age*, vol. 80, no. 31, June 12, 1926, pp. 1670–1672, *gp*)

SPECIAL PROCESSES (See Engineering Materials: Adhesives and Adhesive Action)

STEAM ENGINEERING (See Power-Plant Engineering: The Future of the Steam Engine)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Tentative American Standard for Steel Pipe Flanges and Flanged Fittings

For Maximum Working Steam Pressures of 250, 400, 600, and 900 Lb. per Sq. In. at a Temperature of 750 Deg. Fahr.

IN THE Spring of 1920 the American Engineering Standards Committee authorized the organization of a Sectional Committee on the Standardization of Pipe Flanges and Fittings for the purpose of unifying the flanged- and screwed-fitting standards in force in this country. This Sectional Committee is sponsored by the Heating and Piping Contractors National Association, the Manufacturers Standardization Society of the Valve and Fittings Industry (formerly known as the Committee of Manufacturers on Standardization of Fittings and Valves) and The American Society of Mechanical Engineers.

This Sectional Committee had not progressed very far with its work when it realized that the standardization of steel flanges and flanged fittings was very greatly needed. An informal conference on this subject which the sponsors held on May 23, 1923, indicated such widespread interest in this subject that it was decided to organize immediately a new sub-committee to develop standards for steel flanges to withstand high superheat temperatures and pressures from 250 to 3200 lb. per sq. in.

Accordingly, at an open meeting of this Sub-Committee, designated as Sub-Committee No. 3, held in the Engineering Societies

TABLE 5 FACING DIMENSIONS FOR THE AMERICAN 250, 400, 600, AND 900-LB. STEEL FLANGES AND FLANGED FITTINGS

	Outside diameter[3]				Outside diameter[3]				Height		
Nominal pipe size	Raised face Van Stone, large male and large tongue[5] R	Small male[4,5] S	Small tongue[5] T	I.D. of large and small tongue[3,5] U	Large female and large groove[5] W	Small female[4,5] X	Small groove[5] Y	I.D. of large and small groove[3,5] Z	Raised face 250 stds.[1]	Raised face, large and small male and tongue 400, 600, and 900 lb. stds.[2]	Depth of groove for female companion flanges
1/2	1 3/8	23/32	1 3/8	1	1 7/16	25/32	1 7/16	15/16	1/16	1/4	3/16
3/4	1 11/16	15/16	1 11/16	1 5/16	1 3/4	1	1 3/4	1 1/4	1/16	1/4	3/16
1	2	1 3/16	1 7/8	1 1/2	2 1/16	1 1/4	1 15/16	1 7/16	1/16	1/4	3/16
1 1/4	2 1/2	1 1/2	2 1/4	1 7/8	2 9/16	1 9/16	2 5/16	1 13/16	1/16	1/4	3/16
1 1/2	2 7/8	1 3/4	2 1/2	2 1/8	2 15/16	1 13/16	2 9/16	2 1/16	1/16	1/4	3/16
2	3 5/8	2 1/4	3 1/4	2 7/8	3 11/16	2 5/16	3 5/16	2 13/16	1/16	1/4	3/16
2 1/2	4 1/8	2 11/16	3 3/4	3 3/8	4 3/16	2 3/4	3 13/16	3 5/16	1/16	1/4	3/16
3	5	3 5/16	4 5/8	4 1/4	5 1/16	3 3/8	4 11/16	4 3/16	1/16	1/4	3/16
3 1/2	5 1/2	3 13/16	5 1/8	4 3/4	5 9/16	3 7/8	5 3/16	4 11/16	1/16	1/4	3/16
4	6 3/16	4 5/16	5 11/16	5 3/16	6 1/4	4 3/8	5 3/4	5 1/8	1/16	1/4	3/16
5	7 5/16	5 3/8	6 13/16	6 5/16	7 3/8	5 7/16	6 7/8	6 1/4	1/16	1/4	3/16
6	8 1/2	6 3/8	8	7 1/2	8 9/16	6 7/16	8 1/16	7 7/16	1/16	1/4	3/16
8	10 5/8	8 3/8	10	9 3/8	10 11/16	8 7/16	10 1/16	9 5/16	1/16	1/4	3/16
10	12 3/4	10 1/2	12	11 1/4	12 13/16	10 9/16	12 1/16	11 3/16	1/16	1/4	3/16
12	15	12 1/2	14 1/4	13 1/2	15 1/16	12 9/16	14 5/16	13 7/16	1/16	1/4	3/16
14 O.D.	16 1/4	13 3/4	15 1/2	14 3/4	16 5/16	13 13/16	15 9/16	14 11/16	1/16	1/4	3/16
16 O.D.	18 1/2	15 3/4	17 5/8	16 3/4	18 9/16	15 13/16	17 11/16	16 11/16	1/16	1/4	3/16
18 O.D.	21	17 3/4	20 1/8	19 1/4	21 1/16	17 13/16	20 3/16	19 3/16	1/16	1/4	3/16
20 O.D.	23	19 3/4	22	21	23 1/16	19 13/16	22 1/16	20 15/16	1/16	1/4	3/16
24 O.D.	27 1/4	23 3/4	26 1/4	25 1/4	27 5/16	23 13/16	26 5/16	25 3/16	1/16	1/4	3/16
					Special Sizes						
4 1/2	6 3/4	4 13/16	6 1/4	5 3/4	6 13/16	4 7/8	6 5/16	5 11/16	1/16	1/4	3/16
7	9 5/8	7 3/8	9	8 3/8	9 11/16	7 7/16	9 1/16	8 5/16	1/16	1/4	3/16

All dimensions given in inches.

[1] Regular facing for 250-lb. flange standard is a 1/16-in. raised face included in the minimum flange-thickness dimensions given in Table 6. A 1/16-in. raised face is also permitted on the 400, 600, and 900-lb. flange standards, but it must be added to the minimum flange thickness.

[2] Regular facing for 400, 600, and 900-lb. flange standards is a 1/4-in. raised face not included in minimum flange-thickness dimensions given in Tables 7 to 12, inclusive. See illustrations with tables showing application of various facings.

[3] A tolerance of plus or minus 0.016 in. (1/64 in.) is allowed on the inside and outside diameters of all facings.

[4] Care should be taken in the use of joints of these dimensions, as they apply particularly on lines where the joint is made on the end of pipe to insure that pipe used is thick enough to permit sufficient bearing surface to prevent crushing the gasket.

[5] Gaskets for male, female, and tongue-groove joints shall cover the bottom of the recess with minimum clearances taking into account the tolerances prescribed in Note 3.

250-Lb. Steel Flanged Fittings

TABLE 6 DIMENSIONS OF STEEL FLANGED FITTINGS WITH PROJECTING FACES FOR MAXIMUM WORKING STEAM PRESSURE OF 250 LB. PER SQ. IN. AT A TEMPERATURE OF 750 DEG. FAHR.[4]

Nominal pipe size	Inside diameter of fitting	Minimum metal thickness of fitting	Outside diameter of flange	Minimum thickness of flange[1]	Diameter of bolt circle	Number of bolts	Size of bolts	Center to contact surface of raised face elbow, tee, and cross[1,2,3]	Center to contact surface of raised face, 45° ell[1,2,3]	Center to contact surface of raised face, long-radius ell[1,2,3]	Long center to contact surface of raised face, lateral[1,2,3]	Short center to contact surface of raised face, lateral[1,2,3]	Contact surface to contact surface, reducer[1,2,3]
2	2	1/4	6 1/2	7/8	5	8	5/8	5	3	6 1/2	9	2 1/2	5
2 1/2	2 1/2	1/4	7 1/2	1	5 7/8	8	3/4	5 1/2	3 1/2	7	10 1/2	2 1/2	5 1/2
3	3	1/4	8 1/4	1 1/8	6 5/8	8	3/4	6	3 1/2	7 3/4	11	3	6
3 1/2	3 1/2	9/32	9	1 3/16	7 1/4	8	3/4	6 1/2	4	8 1/2	12 1/2	3	6 1/2
4	4	5/16	10	1 1/4	7 7/8	8	3/4	7	4 1/2	9	13 1/2	3	7
5	5	3/8	11	1 3/8	9 1/4	8	3/4	8	5	10 1/4	15	3 1/2	8
6	6	3/8	12 1/2	1 7/16	10 5/8	12	3/4	8 1/2	5 1/2	11 1/2	17 1/2	4	9
8	8	7/16	15	1 5/8	13	12	7/8	10	6	14	20 1/2	5	11
10	10	15/32	17 1/2	1 7/8	15 1/4	16	1	11 1/2	7	16 1/2	24	5 1/2	12
12	12	1/2	20 1/2	2	17 3/4	16	1 1/8	13	8	19	27 1/2	6	14
14 O.D.	13 1/4	17/32	23	2 1/8	20 1/4	20	1 1/8	15	8 1/2	21 1/2	31	6 1/2	16
16 O.D.	15 1/4	19/32	25 1/2	2 1/4	22 1/2	20	1 1/4	16 1/2	9 1/2	24	34 1/2	7 1/2	18
18 O.D.	17	5/8	28	2 3/8	24 3/4	24	1 1/4	18	10	26 1/2	37 1/2	8	19
20 O.D.	19	11/16	30 1/2	2 1/2	27	24	1 3/8	19 1/2	10 1/2	29	40 1/2	8 1/2	20
24 O.D.	23	13/16	36	2 3/4	32	24	1 5/8	22 1/2	12	34	47 1/2	10	24
						Special Sizes							
4 1/2	4 1/2	5/16	10 1/2	1 5/16	8 1/2	8	3/4	7 1/2	4 1/2	9 1/2	14 1/2	3 1/2	7 1/2
7	7	13/32	14	1 1/2	11 7/8	12	7/8	9	6	12 3/4	19	4 1/2	10

All dimensions given in inches.

[1] A raised face of 1/16 in. is included in (*a*) minimum thickness of flanges, (*b*) center-to-contact-surface dimensions, and (*c*) contact-surface-to-contact-surface dimension. Inasmuch as the 1/16-in. raised face is cut from the flange thickness, the center-to-contact-surface dimensions are the same as the center-to-flange-edge dimensions in this standard for this type of facing.

[2] Where facings other than the 1/16-in. raised face are used, the "center-to-flange-edge" dimensions shall remain unchanged, and the new "center-to-contact-surface," or the new "contact-surface-to-contact-surface" dimensions shall be established to suit the facing used.

[3] This standard provides for a 1/16-in. raised face on all openings of flanged fittings.

[4] The fittings incorporated in this table are also suitable for other pressure and temperature ratings shown in Table 1.

400-LB. STEEL FLANGED FITTINGS

TABLE 7 CENTER-TO-CONTACT-SURFACE DIMENSIONS OF FLANGED FITTINGS FOR MAXIMUM WORKING STEAM PRESSURE OF 400 LB. PER SQ. IN. AT A TEMPERATURE OF 750 DEG. FAHR.[3]

Nominal pipe size	Inside diameter of fitting	Minimum metal thickness of fitting	Outside diameter of flange	Minimum thickness of flange	Diameter of bolt circle	Number of bolts	Size of bolts	*AA* Center to contact surface of raised face, elbow, tee, and cross[1,2]	*CC* Center to contact surface of raised face, 45° ell[1,2]	*EE* Long center to contact surface of raised face, lateral[1,2]	*FF* Short center to contact surface of raised face, lateral[1,2]	*GG* Contact surface to contact surface, reducer[1,2]
1/2	1/2	1/4	3 3/4	9/16	2 5/8	4	1/2	3 1/4	2	5 1/2	1 3/4	5
3/4	3/4	1/4	4 5/8	5/8	3 1/4	4	5/8	3 3/4	2 1/4	6 1/2	2	5
1	1	1/4	4 7/8	11/16	3 1/2	4	5/8	4 1/4	2 1/4	6 3/4	2 1/4	5
1 1/4	1 1/4	1/4	5 1/4	13/16	3 7/8	4	5/8	4 1/2	2 3/4	7 1/2	2 1/2	5
1 1/2	1 1/2	1/4	6 1/8	7/8	4 1/2	4	3/4	4 3/4	3	8 3/4	2 3/4	5
2	2	1/4	6 1/2	1	5	8	5/8	5 3/4	4 1/4	11	3 1/2	6
2 1/2	2 1/2	5/16	7 1/2	1 1/8	5 7/8	8	3/4	6 1/2	4 1/2	12	3 1/2	6 3/4
3	3	5/16	8 1/4	1 1/4	6 5/8	8	3/4	7	5	13 1/2	4	7 1/4
3 1/2	3 1/2	3/8	9	1 3/8	7 1/4	8	7/8	7 1/2	5 1/2	14 1/2	4 1/2	7 3/4
4	4	3/8	10	1 3/8	7 7/8	8	7/8	8	5 1/2	15 1/4	4 1/2	8 1/4
5	5	7/16	11	1 1/2	9 1/4	8	7/8	9	6	16 3/4	5	9 1/4
6	6	7/16	12 1/2	1 5/8	10 5/8	12	7/8	9 3/4	6 1/4	17 3/4	5 1/4	10
8	8	9/16	15	1 7/8	13	12	1	11 3/4	6 3/4	22 1/4	5 3/4	12
10	10	11/16	17 1/2	2 1/8	15 1/4	16	1 1/8	13 1/4	7 3/4	25 3/4	6 1/4	13 1/2
12	12	3/4	20 1/2	2 1/4	17 3/4	16	1 1/4	15	8 3/4	29 3/4	6 1/2	15 1/4
14 O.D.	13 1/8	13/16	23	2 3/8	20 1/4	20	1 1/4	16 1/4	9 1/4	32 3/4	7	16 1/2
16 O.D.	15	7/8	25 1/2	2 1/2	22 1/2	20	1 3/8	17 3/4	10 1/4	36 1/4	8	18 1/2
18 O.D.	17	15/16	28	2 5/8	24 3/4	24	1 3/8	19 1/4	10 3/4	39 1/4	8 1/2	19 1/2
20 O.D.	18 7/8	1 1/16	30 1/2	2 3/4	27	24	1 1/2	20 3/4	11 1/4	42 3/4	9	21
24 O.D.	22 5/8	1 3/16	36	3	32	24	1 3/4	24 1/4	12 3/4	50 1/4	10 1/2	24 1/2
						SPECIAL SIZES						
4 1/2	4 1/2	7/16	10 1/2	1 7/16	8 1/2	8	7/8	8 1/2	5 3/4	16 1/4	4 3/4	8 3/4
7	7	1/2	14	1 3/4	11 7/8	12	1	10 3/4	6 3/4	20 3/4	5 1/2	11

All dimensions given in inches.

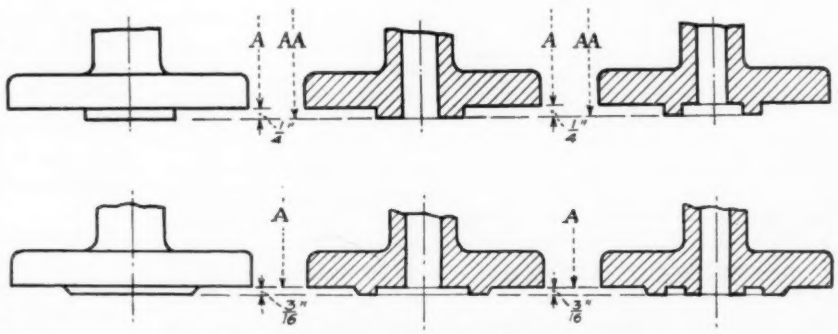
[1] A raised face of 1/4 in. is not included in the minimum thickness of flanges, but is included in center-to-contact surface of raised-face dimensions, and contact-surface-to-contact-surface dimensions.

[2] Where facings other than the 1/4-in. raised face are used, the "center-to-flange-edge" dimensions shown in Table 8 shall remain unchanged, and the new "center-to-contact-surface," or the new "contact-surface-to-contact-surface" dimensions shall be established to suit the facing used.

[3] The fittings incorporated in this table are also suitable for other pressure and temperature ratings shown in Table 1.

Building, Friday, October 26, 1923, and attended by fifty engineers, manufacturers, and users of this product, a comprehensive program for the standardization of steel flanges and flanged fittings was launched; and in June of this year, after two and a half years of painstaking endeavor, a Tentative Standard was reported. Prof. Collins P. Bliss is chairman of the Sectional Committee, as well as of Sub-Committee No. 3.

While, as indicated above, this Tentative Standard is designed for maximum working steam pressures of 250, 400, 600, and 900 lb. per sq. in. at a temperature of 750 deg. fahr., it is also designed for maximum non-shock working hydraulic pressures of 325, 500, 720, and 1080 lb. per sq. in. at 450 deg. fahr., and for maximum non-shock working hydraulic pressures of 500, 750, 1000, and 1500 lb. at near the ordinary range of air temperatures.



GROOVE AND FEMALE FACINGS FOR SPECIAL FITTINGS

The Standard comprises 8 dimensional tables prefaced by a number of pages of introductory and explanatory notes. These notes deal with pressure ratings and tests; size of fittings; marking; materials (including tables of physical and chemical requirements of

TABLE 8 CENTER-TO-FLANGE-EDGE DIMENSIONS OF FLANGED FITTINGS FOR MAXIMUM WORKING STEAM PRESSURE OF 400 LB. PER SQ. IN., AT A TEMPERATURE OF 750 DEG. FAHR.[3]

Nominal pipe size	Inside diameter of fitting	Minimum metal thickness of fitting	Outside diameter of flange	Minimum thickness of flange[1]	Diameter of bolt circle	Number of bolts	Size of bolts	*A* Center to flange edge, elbow, tee, and cross[1,2]	*C* Center to flange edge, 45° ell[1,2]	*E* Long center to flange edge, lateral[1,2]	*F* Short center to flange edge, lateral[1,2]	*G* Flange edge to flange edge, reducer[1,2]
1/2	1/2	1/4	3 3/4	9/16	2 5/8	4	1/2	3	1 3/4	5 1/4	1 1/2	4 1/2
3/4	3/4	1/4	4 5/8	5/8	3 1/4	4	5/8	3 1/2	2	6 1/4	1 3/4	4 1/2
1	1	1/4	4 7/8	11/16	3 1/2	4	5/8	4	2	6 1/2	2	4 1/2
1 1/4	1 1/4	1/4	5 1/4	13/16	3 7/8	4	5/8	4 1/4	2 1/2	7 1/4	2 1/4	4 1/2
1 1/2	1 1/2	1/4	6 1/8	7/8	4 1/2	4	3/4	4 1/2	2 3/4	8 1/2	2 1/2	4 1/2
2	2	1/4	6 1/2	1	5	8	5/8	5 1/2	4	10 3/4	3 1/4	5 1/2
2 1/2	2 1/2	5/16	7 1/2	1 1/8	5 7/8	8	3/4	6 1/4	4 1/4	12 1/4	3 1/4	6 1/4
3	3	5/16	8 1/4	1 1/4	6 5/8	8	3/4	6 3/4	4 3/4	13 1/4	3 3/4	6 3/4
3 1/2	3 1/2	3/8	9	1 3/8	7 1/4	8	7/8	7 1/4	5 1/4	14 1/4	4 1/4	7 1/4
4	4	3/8	10	1 3/8	7 7/8	8	7/8	7 3/4	5 1/4	15	4 1/4	7 3/4
5	5	7/16	11	1 1/2	9 1/4	8	7/8	8 3/4	5 3/4	16 1/2	4 3/4	8 3/4
6	6	7/16	12 1/2	1 5/8	10 5/8	12	7/8	9 1/2	6	17 1/2	5	9 1/2
8	8	9/16	15	1 7/8	13	12	1	11 1/2	6 1/2	22	5 1/2	11 1/2
10	10	11/16	17 1/2	2 1/8	15 1/4	16	1 1/8	13	7 1/2	25 1/2	6	13
12	12	3/4	20 1/2	2 1/4	17 3/4	16	1 1/4	14 3/4	8 1/2	29 1/2	6 1/4	14 3/4
14 O.D.	13 1/8	13/16	23	2 3/8	20 1/4	20	1 1/4	16	9	32 1/2	6 3/4	16
16 O.D.	15	7/8	25 1/2	2 1/2	22 1/2	20	1 3/8	17 1/2	10	36	7 3/4	18
18 O.D.	17	15/16	28	2 5/8	24 3/4	24	1 3/8	19	10 1/2	39	8 1/4	19
20 O.D.	18 7/8	1 1/16	30 1/2	2 3/4	27	24	1 1/2	20 1/2	11	42 1/2	8 3/4	20 1/2
24 O.D.	22 5/8	1 3/16	36	3	32	24	1 3/4	24	12 1/2	50	10 1/4	24
						SPECIAL SIZES						
4 1/2	4 1/2	7/16	10 1/2	1 7/16	8 1/2	8	7/8	8 1/4	5 1/2	16	4 1/2	8 1/4
7	7	1/2	14	1 3/4	11 7/8	12	1	10 1/2	6 1/2	20 1/2	5 1/4	10 1/2

All dimensions given in inches.

[1] A raised face of 1/4 in. is not included in (*a*) minimum thickness of flanges, (*b*) center-to-flange-edge dimensions, or (*c*) flange-edge-to-flange-edge dimensions.

[2] Where facings other than the 1/4-in. raised face are used the "center-to-flange-edge" dimensions shall remain unchanged, and the new "center-to-contact-surface" dimensions shall be established to suit the facing used.

[3] The fittings incorporated in this table are also suitable for other pressure and temperature ratings shown in Table 1.

steel castings for flanges, fittings, and valves, of alloy-steel bolting material, and of forged steel flanges); facings; bolting; spot-facing; metal thickness; fitting dimensions; laterals; valve dimensions; and reducing fittings. The tables for 250-lb. and 400-lb. fittings at a temperature of 750 deg. fahr. are reproduced on the preceding page; similar tables for 600-lb. and 900-lb. fittings are included in the Tentative Standard.

This Standard has been approved by letter-ballot of the members of the Sectional Committee and is now before the three sponsor organizations for approval and transmission to the American Engineering Standards Committee. Copies of the Standard in page-proof form are now available to those specially interested, and may be procured from the A.S.M.E., 29 West 39th Street, New York, N. Y.

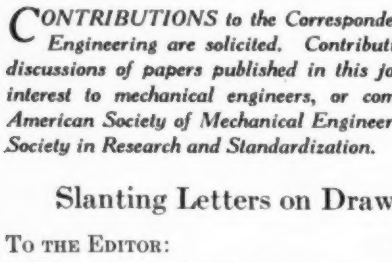
Correspondence

Contributions to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities or policies of the Society in Research and Standardization.

Slanting Letters on Drawings Save Money

To the Editor:

The writer read with much interest Mr. Harper's letter on page 624 of the June issue of Mechanical Engineering, and heartily agrees with his views on slanting letters and on labor-saving center, dimension projection, and dimension lines. He notes, however, that no change has been made in the style of arrow heads. He has found in his past tracing experience that much time can be saved by not filling in the arrow heads solid, but making them as two single lines. If the arrow heads are done neatly, it is believed that they will be as clearly understood as the solid ones. Perhaps this may be considered only a small item but in a drafting room where a large force of tracers is required, much time can be saved by attention to small matters, and time means money.



If Mr. Harper has any special reasons for using solid arrow heads, the writer would be pleased to learn what they are.

J. Russell Reiner.[1]

Philadelphia, Pa.

Teaching Mechanical Drawing at the Ford Apprentice School

To the Editor:

This year the writer has introduced a system of teaching for a large class of mechanical-drawing students which may be of interest to others, and possibly some may find it very helpful.

We have procured a Spencer automatic delineascope, which projects a 5-ft. by 6-ft. picture on a screen. We have made films the size of motion-picture films of all our standard lesson sheets of mechanical drawing, also of free-hand sketch sheets. With this form of instruction our instructors can place before a class of thirty or forty an illustration of any lesson on the course. They can stand by the screen with an electric button in one hand and a pointer in the other, and project any view, detail, assembly, or series of operations until a thorough explanation has been given. We use a standard lesson sheet held to slanting tables by patent inserted clamps. The T-squares are set in grooves in the tables and remain in position for all students. We have an enrolment of six hundred, composed of boys from production departments, patternmaking apprentices, tool- and die-making apprentices, drafting apprentices, and production foremen.

With regard to the standardization of drawing practices, we have set our own standards to meet the particular needs of our factory, and these we judge to be some of the shortest quick-cut methods in the world. We judge these only at the present time by the rate we manufacture the Ford car. This is not saying that there are no other standards we should not be willing to adopt, provided they help universally.

With regard to the article in the June, 1926, issue by John Harper, we agree with him that the plain block slanting letters are among the best for a standard on shop drawings. We have used these for the past ten years and we have gone so far as to standardize the size to $^3/_{32}$ in. in height for all letters, titles included.

In conclusion, the writer wishes to state that in his estimation a great deal of good can be done by forcing, if possible, some universal standards into general use throughout this country. If mechanical drawing is becoming a greater universal language for all shop men, why not adopt as nearly as possible one language, readable alike in all shops. Thousands of books are taking up shelf room and spreading out to ignorant shop men a thousand ways of expressing the same thing by a thousand different symbols. These should be discarded and universal standards adopted.

Wm. C. Pickell.[1]

Highland Park, Mich.

Open-Side Machine Frames

To the Editor:

In the issues of Mechanical Engineering for November, 1925, and June, 1926, the writer notices some discussions on the design of open-side frames, such as are used for presses and riveters.

In the June issue Professor Frocht asks for some experimental evidence as to the relative strength of different shapes. On pages 39–47 of Benjamin and Hoffman's Machine Design (Henry Holt & Co., 1913) are given some results of experiments reported in 1910 by Prof. A. L. Jenkins [Trans. A.S.M.E., vol. 32 (1910), p. 311], and also of experiments conducted in 1912 at Purdue University under the direction of the writer.

Professor Jenkins showed the weakness of the rectangular type as always breaking at the corners of the opening. His experiments also indicated that a thickening of the web rather than of the flange increased the strength.

In the Purdue tests the proportions of the frames were similar to those of a modern hydraulic riveter, modifications being made in the dimensions of the flanges and fillets as the tests progressed.

One-half of the twenty-four specimens broken failed by splitting of the web in a curved line just back of the throat flange. Radial flanges prevented this and increased the strength about fifty per cent. Thickening the web increased the strength further to nearly double that of the original model. Practically every line of fracture followed the outline of some flange, showing the presence of shrinkage strains.

Detailed information in regard to the Purdue experiments can probably be obtained by communication with Prof. G. A. Young (Mem. A.S.M.E.) at Purdue University, LaFayette, Indiana.

C. H. Benjamin.[2]

Altadena, Cal.

[1] Designer, Hoist Dept., American Engineering Co. Jun. A.S.M.E.

[1] Drawing Instructor in Charge, Ford Apprenticeship School.

[2] Retired Dean of Engineering, Purdue University of Lafayette, Ind. Mem. A.S.M.E.

A Simple Mechanism for Transforming Circular into Rectilinear Motion[1]

To the Editor:

In certain types of instruments it is desired to have a simple mechanism to convert a motion of rotation into a motion along a straight line or an approximately straight line. The mechanism, however, must in most cases have a minimum of friction and in addition must be of a rugged construction.

A mechanism that meets these requirements is shown in Fig. 1 and consists of the three arms *AB*, *BC* and *OD*. The motion of the arm *OD* about the fixed pivot *O* constitutes the motion of rotation which is to be converted into a straight-line motion. *OD* is pinned to the arm *AB* at *D*. The arm *BC* rotates about the fixed point *C* and is pinned to *AB* at *B*. Then as *OD* rotates, the point *A* of the arm *AB* (i.e., the tip of the pointer) moves along the approximately straight line *AE*. The positions of the fixed points *O* and *C* should be determined experimentally, but as shown are arranged approximately as used in a mechanism of this type constructed at the Bureau of Standards. Assuming the length of *AE*, the relative proportions of the various elements of the mechanism constructed are as follows: $OD = 0.35\,AE$, $AB = 1.15\,AE$, and $AD = 0.67\,AE$. *BC* must be greater than $0.4\,AE$. θ_1 and θ_2 should not exceed 40 deg., since rotation beyond these limits produces a rapid deviation from the straight-line motion of the pointer.

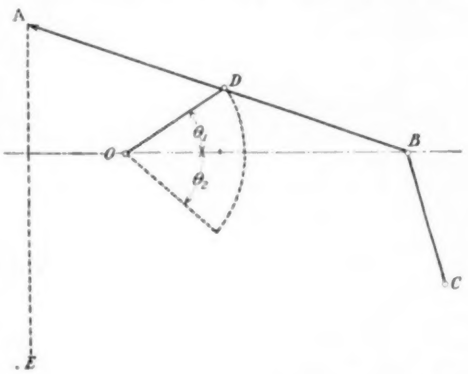


Fig. 1 Mechanism for Transforming Circular into Rectilinear Motion

W. W. Frymoyer.[2]

Washington, D. C.

Design and Test of Susquehanna Station

To the Editor:

Referring to the communication from J. N. Landis, published on page 625 of Mechanical Engineering for June, the writer would say that all figures in Table 5 of Mr. Gilbert's paper on the Susquehanna Station[3] are average results with the exception of the heat transfer, this representing the result of the first twelve hours of the test, during which the condenser was substantially clean.

The writer wishes to call attention to the fact that, due to rapid fouling, it was necessary to clean the condenser during the test. Therefore the average B.t.u. transfer during the test should not be compared to manufacturers' guarantees, which are always based on a clean condenser.

Properly in the tabulations of the condenser results the heat transfer should have been omitted, and simply a statement made comparing the results from a clean condenser with the manufacturers' guarantees. It is hoped, however, that this letter will explain the differences between the figures in the table and those of Mr. Landis'.

The purpose of the test on the Susquehanna plant was to get overall results and, while readings were taken on each piece of equipment, the intent of the paper was merely to present observations taken on the various apparatus, the main idea being the discussion of the overall results.

Reading, Pa. J. A. Powell.[4]

[1] Published by Permission of the Director of the National Bureau of Standards of the U. S. Department of Commerce.

[2] Assistant Mechanical Engineer, U. S. Bureau of Standards, Jun. A.S.M.E.

[3] Design and Test of the Susquehanna Station, Mechanical Engineering, April, 1926, p. 362.

[4] Mechanical Engineer, The W. S. Barstow Management Association, Inc.

Tapered-Roller Bearings

To the Editor:

May I call the attention of the readers of the Mechanical Engineering to a misleading statement made by the late A. A. Macaulay in his very excellent handbook on Ball and Roller Bearings. Referring to tapered-roller bearings, he states (p. 72):

> The deformation throughout the roller length should be proportional to the diameter at that point, which implies a certain shaft deflection to give the requisite load distribution; in other words, a rigid shaft with the tapered-roller bearing does not strictly give the proper condition for perfect running.

A little consideration will make clear that the above statement is erroneous. The load capacity of a roller is proportional to the square of the diameter at the point where the load is applied. Therefore, if the total load on a tapered roller were to be evenly distributed (which would happen if the deflection were even throughout) the small end of the roller would be stressed more than the large end, resulting in a decreased capacity of the whole bearing. Thus the rigidity of the shaft insures a proper distribution of stress, giving the tapered-roller bearing its reputed high capacity.

Proper performance at high speed and when great precision is required must be the practical test for the proper condition of perfect running. The remarkable success of the tapered-roller bearing in milling-machine spindles and in grinding spindles with such speeds as 1500 r.p.m. (tests made by Timken Roller Bearing Co.) is a convincing proof that the taper principle is correct.

A. R. Spicacci.

Canton, Ohio.

The Earnings of Engineers

To the Editor:

Mr. H. M. Dougherty's letter on The Earnings of Engineers which appeared in the April issue of Mechanical Engineering prompts the writer to call the attention of its readers to the following

The engineering societies and Mr. Hoover are devoting much of their time to the conservation of our natural resources like coal, etc. What about the conservation of our resources of engineering knowledge, experience, and skill? The latter are much more valuable than the former, because if we exhaust our coal supply our engineers will find other sources of power, but if we waste our engineering knowledge, experience, and skill, no amount of coal will build us bridges across the great rivers, automatic machinery to do the work of multitudes of human beings, or countless other things that only men with technical training and the engineering skill that comes from years of experience in applying this training can do. And yet our engineering resources are constantly wasted by unwise management. Men with good training, long experience, and especially adapted to engineering work are constantly being forced out of our ranks by inadequate remuneration to become farmers, salesmen, business men, and agents.

A recent case that happened very close to the writer is that of an engineer with a good training and experience, a man whose name appears in Who's Who in Engineering, a man who is the author of a highly technical book, and who was mechanical superintendent of the second largest plant in its line in the world. He was in charge of maintenance shops which had a yearly output of over a million and a half dollars. This man was getting little more than a carpenter foreman and was obliged to quit his job because the company would not raise his compensation to a fair level. Now he is in the restaurant business, about which he knows nothing except that it pays.

His experience is lost to industry, and the contributions which he would have continued to make to technical literature are stopped because from now on his experience will be in buying raw food and selling it cooked. Doubtless all of us know of similar cases. Examples need not be multiplied.

Why don't the engineering societies stop this leak in the nation's resources? Engineering experience teaches us—no matter how much we wish it were otherwise—that performance is closely linked with compensation. We institute wage-incentive systems for the workman, and in the January issue of Mechanical Engineering

there is an appeal to aid a bill providing more money for our honorable federal judges. This is quite logical. Let us include in this program the engineers also. It will benefit everybody. The good men will not be tempted by more profitable fields, the industries will be run better, and engineers will not be martyrs just because they are absorbed in productive work and do not set aside a great portion of their time and energy to haggling and scheming "to get the money" as business men and union labor do.

Mr. Dougherty's suggestion that the engineering societies appoint a joint committee is very much to the point. The writer would like to add, however, that because larger bodies are necessarily slower in starting and acquiring momentum, the A.S.M.E. should appoint a committee of its own which should be empowered to join with similar committees of the other engineering societies. Another reason why the A.S.M.E. should take the first step in this matter is that mechanical engineers have paid more attention to management-engineering problems than other engineers, and this is evidently a problem in management engineering.

Mechanical Engineer.

Technical Training in Woodworking

To the Editor:

The article by Thomas D. Perry, entitled Technical Training in Woodworking, which appeared in the February issue of Mechanical Engineering, has interested me very much, for the reasons (1) that I have, from a boy, been devoted to such work as a pastime or hobby, and believe myself as able a craftsman in such work as most men who have devoted their life to the trade; (2) I taught woodwork in one of our largest and best-equipped manual-training high schools, for one year only it is true, and this in 1906–07, but with the result that I became thoroughly convinced of the practicability of making woodworking a very valuable course for boys, not merely as a means of developing more or less manual skill, but of developing their ability to make practical use of *other courses which can be amplified and made tangible through model construction*, namely, geometry, physics, and trigonometry. For example, a rough model of a simple bridge or roof truss, made in a few minutes, will do more to make clear the principles of the triangle or parallelogram of forces, and the statics of the simple truss, than many times the effort if confined to "grinding" or "boning" over a desk. A simple crate, correctly built, is likewise a wonderful means of making clear the nature of stresses existing in such a structure, and the problems that exist in all truss construction. Boys who have had such exercises in the woodshop, intelligently presented by a competent instructor who himself is not only a skilled workman but also a man of sufficient breadth of training and education to grasp the bigger principles involved, will become not only absorbed in such work, but will go forth from such a course with clear conceptions of many of the principles of mechanics and the basic underlying mathematical principles involved, so that whether they leave school for a trade or continue on into university work, they will have acquired a grasp of many of the fundamental relations between abstract mathematics and the practical, tangible exemplification of that science in mechanical and engineering construction.

Any one who has constructed with his own hands a model or piece of mechanism knows exactly what I mean, provided he has had some education in mathematics and physics. The fascination of seeing a tangible elucidation of the dry formulas of the textbook, through the medium of matériel designed and put together by one's own hands and eyes and brain, is something that only model makers, who are also possessed of some knowledge of mathematics and physics, can fully appreciate. And I thoroughly believe that the right kind of an instructor cannot only impart such enthusiasm to the majority of high-school boys, but can make this sort of instruction a very real contribution to the further development of their practical education along mechanical and engineering lines.

So, as in most lines of human endeavor, the final solution of the problem of making woodworking a worthwhile course of instruction depends chiefly upon the qualifications of the instructor. Unless he is able to make his course more than a mere teaching of the use of tools, such training will, and should, continue along the path it now seems to be following, viz., a path which the majority of educators class as among the less important and desirable ones for the training of our youth.

C. L. Williams.[1]

Elyria, Ohio.

[1] Major, U. S. A. Mem. A.S.M.E.

Engineering and Industrial Standardization

Some Questions of Policy in Industrial-Standardization Work

During the year or so that it has been my privilege to attend the meetings of this Committee and of its Executive Committee, I have been deeply impressed by the breadth and diversity of the standardization problem. For upward of thirty years I have been connected with standardization work within one industry—the Bell Telephone System—and it is this work about which I can speak of my own knowledge and experience.

The telephone industry throughout the world is not universally standardized. Within the United States, which has 6 per cent of the world's population and 63 per cent of the world's telephones, standardization has been a vital factor in the development of the telephone art from the beginning. In order to obtain a picture of what happens in a telephone system in the absence of standardization, I shall briefly describe some of the conditions that have obtained in the telephone system in Paris, France, until quite recently. It has been said that in France, telephoning is little more than an adventure in a complex of silence and blasphemy. There the telephone subscriber has bought his instruments from some manufacturer. The Government Telephone Administration has approved about one hundred fifty types of instruments made by about twenty-five different manufacturers. Although the subscriber in France buys his instruments, they are installed by Government employees and the Government maintains them. When the subscriber has some difficulty with his service, he reports it to the telephone administration and in course of time they send a man to the subscriber's premises to make an inspection. He often reports that the difficulty is not in the Government lines, but that it is in the subscriber's instrument and perhaps he tries to correct the fault. If he does not succeed, the subscriber is told that he has a bad set and should take it up with the manufacturer. Then the manufacturer will send some one around to make an examination of the set. He often reports that the difficulty is not in the set at all, but is in the Government line. The result has been a great loss of time to the subscriber and an inconvenience to all other subscribers who want to connect with him.

In the United States, this state of affairs has been avoided in the telephone plant by means of standards. The basis of our work of standardization has been that uniform apparatus and methods and materials are desirable for the following reasons: (1) Standardization makes the best available for all. (2) Standardization reduces cost because, when all companies use the same things, they can be manufactured in the largest quantities and uniformity in output contributes to economies in production. (3) Standardization reduces the cost of carrying stocks of materials and the cost of maintenance and repairs, because fewer parts have to be carried. (4) Standardization reduces the cost of instruction of new employees because there are fewer things to get acquainted with. (5) Standardization reduces accounting costs because there are fewer types

and sizes of materials to keep track of. (6) Standardization minimizes complicated engineering and operating problems that might result from intercommunication between widely divergent systems and apparatus. (7) Standardization renders available enormous supplies of materials and labor in emergencies. (8) Standardization greatly facilitates development work. If everything varied from everything else, there would be no definite point of departure from which to start to improve.

We have not found it advisable to have merely one standard for each thing and to try to force the business arbitrarily to conform to it. We change our standards whenever it is advantageous to do so, and we clearly recognize that special conditions may justify departure from all of them.

We are dealing, in the telephone business, with a living organism—a constantly growing thing—and we must, and do, at all times keep our standards of all kinds under revision to see whether they stand the test that each day applies to them.

Our continuous revision of standards is something more than making verbal changes in the language of specifications or reducing the amount of materials by arbitrary alterations in dimensions or quality. All of our specifications, in the last analysis, are based upon economic considerations or considerations of service.

Relative costs of materials and of different grades of the same material are subject to change; sometimes more rapidly than at other times, and when the market price of some of those which have been specified becomes excessive, other materials or grades of materials become more economical, if technically satisfactory.

Changing from one material or from one grade of material to another usually involves experimentation and development work, and often requires new inventions. Frequently we find that even a minute change from one dimension to another can be made safely only after careful experimentation and preliminary trials, sometimes on an extended scale.

It is always possible to reduce first costs at a sacrifice of service or annual charges. The solution of our problem requires that we make these reductions without such sacrifices. This has been a guiding principle in our standardization work and the results have been of great importance to the public.

In many cases it has been our experience that flexibility of production has been obtained and the path to further improvements kept open by specifying, as far as possible, the performance requirements for completed things. This feature has its advantages from the standpoint of diversifying the raw material demand.

Whether standardization becomes a hindrance or an aid to progress, will, in my opinion, largely depend upon the degree of flexibility of standards that is maintained, which involves a working arrangement so set up as to facilitate revision, and the full utilization of this arrangement by making revisions whenever this can advantageously be done.—F. L. Rhodes in a paper presented at a meeting of the American Engineering Standards Committee.

Industrial Significance of Standardization

STANDARDIZATION stabilizes production and employment, since it makes it safe for the manufacturer to accumulate stock during periods of slack orders, which he cannot safely do with an unstandardized product.

2 It reduces selling cost. This is generally overlooked. Possibilities of reduced costs are generally even greater in distribution than in production.

3 It enables buyer and seller to speak the same language, and makes it possible to compel competitive sellers to do likewise.

4 In thus putting tenders on an easily comparable basis, it promotes fairness in competition, both in domestic and in foreign trade.

5 It lowers unit costs to the public by making mass production possible, as has been so strikingly shown in the unification of incandescent lamps and automobiles.

6 By simplifying the carrying of stocks, it makes deliveries quicker and prices lower.

7 It decreases litigation and other factors tending to disorganize industry, the burden of which ultimately falls upon the public.

8 It eliminates indecision both in production and utilization—a prolific cause of inefficiency and waste.

9 By concentrating on fewer lines it enables more thought and energy to be put into designs, so that they will be more efficient and economical.

10 By bringing out the need of new facts in order to determine what is best, and to secure agreement on moot questions, it acts as a powerful stimulus to research and development—and it is thus in decided contrast to crystallization resulting from fixity of mental attitude.

11 It is one of the principal means of getting the results of research and development into actual use in the industries.

12 It helps to eliminate practices which are merely the result of accident or tradition, and which impede development.

13 By concentration on essentials, and the consequent suppression of confusing elements intended merely for sales effect, it helps to base competition squarely upon efficiency in production and distribution and upon intrinsic merit of product.

14 Standardization is increasingly important for the maintenance and development of foreign trade. There is strategy in nationally recognized "American" specifications.

15 The efficiency of competing countries, increasing through national standardization programs, is liable to transfer competition from foreign markets to our own shores.

16 Joint effort in bringing about standardization within and between industries almost invariably leads to better understanding and to beneficial coöperation along other lines—a step toward the integration of our industries.

Iceless Refrigerator Cars

THE Chicago, North Shore, and Milwaukee Railroad recently placed in service five iceless refrigerator cars for service between Chicago and Milwaukee. The cars are equipped with refrig erating machines consisting of a $2^1/_2$-ton capacity Phoenix unit type twin-cylinder ammonia compressor driven by a $7^1/_2$-hp. 600-volt electric motor through a Morse silent chain totally enclosed and running in oil. Power for the car lights, control, and refrigerating equipment is taken from the motor car next to the refrigerator car by means of a 600-volt jumper, and when the car is at a terminal, power is obtained through a temporary trolley connection. The refrigerator cars are not equipped with traction motors and are handled in trains as trailers.

Circulating water for the ammonia condenser is pumped through a device known as an indoor Spra Tower, which performs the same work as the spray towers placed on the roof of a commercial refrigerating plant. The device is connected to the water jacket of the ammonia condenser and has a motor-driven water pump and fan. Air is driven through a louver in the side of the car and exhausted through a vent in the roof.

Tests of these cars have demonstrated that, when necessary, the entire lading may be frozen, and that it is possible to maintain the temperature in the refrigerating compartment between 40 and 42 deg. at all times. Temperature regulation is effected by means of a General Electric thermostat mounted in the refrigerating compartment and connected electrically to the controller of the compressor motor.

A water-pressure-controlled switch is also connected to the compressor-motor control so that failure of the circulating water will cause the main motor to stop until necessary repairs or adjustments are made. After the car has been tested and made ready by the shop forces the operation of the refrigerating machinery is entirely automatic, except for the starting switches in the compressor- and fan-motor circuits.

The cooling coils in the refrigerator compartment are extra-heavy endless galvanized iron pipe. They are clamped securely to the side walls on a special timber construction and covered by wooden baffle boards. The latter extend from 18 in. above the floor to a line midway between the center of the roof and the side wall. This arrangement permits free circulation of air around the cooling coils. A metal gutter along each side of the car carries away the moisture resulting from frost on the coils. Moisture does not collect on the car floor, and the lading is kept dry and free from contaminating odors by this method of drainage. Electric lights and meat-hook racks complete the equipment in the refrigerator. (*Railway Review*, vol. 78, no. 24, June 12, 1926, pp. 1081–1083, 6 figs., *d*)

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

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Standardization and Quality Production

THE article in this issue by Dr. John Mathews on Present Tendencies in Engineering Materials presents a most interesting point of view with respect to the growing impetus of the standardization movement. Nevertheless, it seems fair to point out that the "haggling, disputing and arguing" during the last twenty-five years by those engaged in the attempt to produce standards has resulted in placing American industry in a position to produce quality goods in quantity and at reasonable prices. That there has been too much "haggling and disputing" will be readily granted by those who have been in the forefront of the standardization work. Much of this, however, has been due to the attempt to reach the ideal up to which Dr. Mathews would like to manufacture, as referred to in his address, which has been quoted and commented on by the technical press.

That the very highest class is not called for by existing specifications is frequently due to objections on the part of manufacturers who are inclined to do what they can to make standard specifications as liberal as possible in order that the maximum part of their production may find a market under them; yet in many cases the manufacturers are the first to insist on writing into the standards the highest possible requirements consistent with commercial production. Perhaps we should get a better understanding of what we mean by a standard if we defined a standard as interpreted by the rules of the American Engineering Standards Committee. For any standard to reach the status of an American Standard, it must be shown to be satisfactory to all interests alike, producer, consumer, and general interests.

Standardization is absolutely no bar to the production of quality goods. On this head I should like to quote the following from a paper read recently before the American Institute of Electrical Engineers, under the title The Work of the Engineering Standards Committee.

> Quality goods can best be secured by one of two methods: (*a*) by the work of the few highly trained and skilled individuals available for the production in a given line, or (*b*) by mass production through the use of perfected methods, perfected machinery and equipment, and so organized that each device or product is of the very highest class and is interchangeable with all others of its class. Quantity production under the first class is impossible, and prices for goods so produced are invariably high. American manufacturers have proved that commodities of the very highest class can be produced by the second method at very low cost, and the necessities, and even luxuries, available to the average American citizen are due to the degree of success already attained in American manufacturing methods through our mass production of standardized goods. While we have done much in this line, much more can be accomplished by a greatly increased program of simplification and standardization.......A proper program of standardization will enable us to continue our high wages and allow us to compete successfully in the markets of the world and provide high-grade commodities at reasonable prices for the use of the masses.

The standardization movement is as broad as industry itself, and the standard specifications in use in the steel industries form but a very small part of the industrial standardization work as a whole. The objections of Dr. Eliot which Dr. Mathews refers to were not to standardization of the raw materials and instrumentalities of production, but to human habits, customs, and methods of work. It would be unfortunate if anything should greatly retard the movement of standardization of goods, which is as natural and desirable an expedient as the standardization of the alphabet, or of railway track, which alone makes it possible for our cars to be transferred from one railway line to another. Such standardization is of incalculable benefit to American industry. The movement toward standardization and simplification has been progressing with a constantly increasing impetus. There will always be a place for specialties such as those described in the latter part of Dr. Mathews' paper, and the production of such specialties should in no way interfere with the general program of standardization of those materials and devices which have reached a stage where quantity production should be carried on.

C. E. Skinner.[1]

Suggestions for Forming the Reading Habit

Imaginative Literature

IT IS DESIRABLE first to find out one's inborn preferences in reading, if they are not already known, and then to follow these preferences with growing enthusiasm, and with increasing breadth of outlook on the literature which is the illuminated record of life.

It should be kept in mind always that reading that is to liberalize should stimulate thought and emotion; for it is through exercise of the mind and heart that one grows in power for wise and upright living. The reading which is forgotten overnight may—like playing solitaire—be useful for restful diversion, but it does not help to build character.

To test native taste in reading, a good method is to select an author for trial, with the aid of more experienced readers; if this author has written in several forms of literary art, make a selection from each and read it carefully. These readings will usually make it clear to the reader whether or not he wishes to continue with this author.

Robert Louis Stevenson may be taken for illustration. To test adventure tales, read The Beach of Falesa in the volume, Island Nights Entertainments; or The Pavilion on the Links in the volume, New Arabian Nights; or the longer story, Ebb Tide. If these tales tend to keep one awake nights with thrillful interest, they might be followed by Kidnapped and David Balfour. For romance, read Prince Otto or The Black Arrow. For gruesome tales, Markheim or Doctor Jekyll and Mr. Hyde.

If the reader has followed thus far, he will surely know whether he wishes to go on.

If Kipling is the chosen writer, one should read some of his earlier stories of India; especially The Man Who Would be King, or Without Benefit of Clergy, or the longer story, Kim. One might try Kipling's poetry by reading The Explorer, or The Sons of Martha, or The Bell Buoy. Or, from Barrack-Room Ballads, Gunga Din, Fuzzy Wuzzy, and Danny Deever.

Here follow miscellaneous suggestions from various authors:

Joseph Conrad: The Planter of Malata in the volume, Within the Tides; Youth; The Rover.

Frank R. Stockton's whimsical stories, especially A Tale of Negative Gravity.

George W. Cable: Any of the short stories in Old Creole Days.

H. C. Bunner: Any of the stories in Short Sixes.

[1] Assistant Director of Engineering, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.; Chairman, American Engineering Standards Committee; Mem. A.S.M.E.

William J. Locke: The Joyous Adventures of Aristide Pujol.
John Galsworthy: Any of the stories in the volume, Caravan.
J. M. Barrie: Any of his plays.
Leonard Merrick: Any of his short stories, or Conrad in Search of His Youth.
Maurice Hewlett: Little Novels of Italy.
James Lane Allen: King Solomon of Kentucky, in the volume, Flute and Violin.
Donn Byrne: Blind Raftery.
J. A. Mitchell: The Pines of Lory.
Jane Barlow: Stopped on Signal, in the volume, Maureen's Fairing.

In somewhat earlier times:
Walter Scott: The Heart of Mid-Lothian, The Antiquary.
W. M. Thackeray: Henry Esmond, Vanity Fair.
Charles Dickens: Tale of Two Cities, Our Mutual Friend.
George Eliot: Silas Marner.

A reader should get from his reading an understanding of human motive and action; not only in the present, but in other times and places. The narrow man is he who knows only about his neighbors of today and yesterday. The broad man has learned something of older civilizations. It is not necessary to read the records of these peoples in the language in which they were written, for all that is best is available in excellent English translations.

Homer's Odyssey has been called "the greatest story in the world;" hence it must be worth reading. A translation by Butcher and Lang is available through Macmillan. If the reader of the Odyssey finds his pulse rate rising as he reads, he might try the Iliad also, and some of the Greek tragedies, especially those of Euripides as translated into rhyming couplets by Prof. Gilbert Murray.

Then the reader might venture on a few books out of the twelve of Virgil's Aeneid. There is a good complete translation of Virgil by John Jackson (Oxford Press).

A little book, Asgard and the Norse Heroes, by Miss. K. F. Boult, in Everyman's Library (Dutton), tells the stories of the Norse mythology; also one may read the great epic of the North in The Fall of the Nibelungs, translated by Margaret Armour (Everyman's Library). Then one may continue by reading The Saga of Grettir the Strong (Everyman's Library), and the Icelandic Laxdaela Saga (J. M. Dent).

William Morris in his Earthly Paradise has retold many of the world's enduring stories; thus he has put the Laxdaela Saga into his own poetic form under the title: The Lovers of Gudrun.

Every reader should have a copy of Palgrave's Golden Treasury of Songs and Lyrics. There are many editions, and several are of such size as will slip easily into one's coat pocket, ready to come forth to fill intervals in the day's work or play. This book is filled with suggestions leading toward all that is best in the poetry of the period it covers.

The writer has told briefly of a few out of his many enthusiasms for books of imaginative literature. It is his hope that these hints may start some engineers toward the formation of the reading habit. It is the start that is important; for when the reader finds how much this habit means in increased power in all of life's activities, increased enjoyment in living, and increased helpfulness to others, he will never stop.

Albert W. Smith.[1]

Accidental Discoveries

IT IS A WELL-KNOWN fact that many inventions and discoveries in what might be called the prehistory of science have been made more or less accidentally. The searcher of the past, having no reliable theory to guide him, went out into the broad fields of experiment as a hunter does, not knowing what he might encounter. At times, because of the lack of reliable theory, he might set out to look for one thing only to find another, and, like Saul, king of Judea, might go to look for an ass and find a kingdom.

A German monk in the course of some obscure experiment mixed charcoal, sulphur, and saltpeter in a mortar. The result was gunpowder, an invention which uprooted the feudal system of Europe, extended the domination of the white man over the known world, and profoundly changed the whole course of history.

Another man boiled rubber in a kettle, and when the kettle upset and the rubber came in contact with sulphur, discovered vulcanizing, without which the modern automobile would be tireless and hence impossible.

A third man tried to light anthracite in a stove, but was unsuccessful as "the hard coal would not burn." Then one day he was called home to dinner in the midst of an experiment and went away without extinguishing the flame of the kindling. When he returned he found a hot bed of coals and thus learned that anthracite must be given time to fire up. Here again the result was a profound revolution, this time in the methods of domestic heating, concentration of the production of domestic fuel in a few counties of the state of Pennsylvania, and the growth of one of the most important national industrial districts.

There has been a feeling of late that the days of such accidental discoveries are over. Only in the movies is the researcher of today pictured as a man working with a few home-made tools in a garret. There has been a tendency of late to believe that scientific progress, new developments, discovery, and invention of new machinery and processes can be made as much a matter of organized business as the production of biscuits or shoes. The Bell Laboratories, the General Electric Company, the Westinghouse Electric, to name but a few concerns, maintain vast and expensively equipped research staffs whose work is embodied in thousands of patents every year. And yet somehow some of the great things are not discovered under the shadow of the time clock; while our scientific theories have apparently reached a high state of perfection, they do not seem always to lead to the discovery of the really big things.

At the General Motors Research Laboratories they had been wondering for a long time why automobile engines under certain conditions knocked. The cause was easily traced to the fuel, and some one in the Laboratories conceived the idea that if the color of the fuel were properly changed the engine might stop knocking. The theory proved ultimately to be entirely wrong, but here is what happened. The member of the staff who conceived this bright idea went to the chemical storeroom and asked for a coloring material that would completely dissolve in gasoline. The storekeeper did not know offhand of any such material, but when he looked over the shelves his glance fell on a bottle of iodine and he handed that out in the belief that iodine would dissolve in the gasoline and would certainly give it a color. As the experimenter did not know what color, if any, would produce the desired effect, he tried iodine, with the result that the knocking disappeared.

Now, out of some 10,000 bottles in the storeroom of the Laboratories there was just one bottle that contained a material that would eliminate knocking, and that was the bottle containing iodine, and purely by chance was this particular material tried out of the thousands of materials available. The successful performance of iodine made it possible to develop the true theory of knocking, and this in its turn led to the discovery of anti-detonants, which promises to revolutionize the design of automobile and airplane engines.

The *Scientific American* for July, 1926, reports another similar incident. The laboratories of the E. I. DuPont de Nemours & Co., Wilmington, Del., were working on the development of a quick-drying finish for automobiles, furniture, etc. The development of this new finish began with nitrocellulose, but the preparations first available did not contain enough nitrated cotton to produce a body of lacquer that would stand up under usage. Chemists tried to put in more nitrated cotton, but immediately the solution became more or less jelly-like, and there was no way to spread it out smoothly. As first prepared it was thin enough to use, but it left too thin a coat. With added nitrated cotton it would leave a thick coat, but was too thick to spread.

For a long time the experiments seemed to stand still, or at best to progress very slowly; and then an accident occurred, which provided the romance which sometimes relieves the patient drudgery of a chemist's life.

A new batch of this thick stuff had been assembled and was in a large container ready to go to the mixing machine. It was summer time. The laboratory was warm and, as a matter of experiment, some caustic soda had been put into the mixture. But just as the

[1] Dean Emeritus, Sibley College, Cornell University, Ithaca, N. Y. Mem. A.S.M.E.

jelly was about to be put into the mixer, the machine broke down. It was difficult to repair it, and the container with the compound stood idly by for several days while repairs were under way. Finally, when the mixer was in working order again, the container was wheeled out, the lid was taken off, and to the amazement of every one the jelly-like mass had become almost as thin as water, and almost as clear. Here it was—apparently—the very stuff for which the chemists had been looking for several years.

Why it was thin the chemists did not know, but after all, the why was less important than the how. So they investigated, and found that apparently certain chemicals, together with the summer temperature and the waiting, had rearranged the molecules somehow or other, and had thus changed the consistency of the mixture.

Engineering Education

JUST as in the primary grades of common-school education modern educators are no longer convinced of the sufficiency of the three R's, so in engineering education there is a growing tendency to go far beyond the purely technical subjects to which the curriculum was limited only a few years ago.

When we read the biographies of men like Nasmyth in England or Sweet in this country and compare what they learned with what an engineer has to learn today in his four or five years at college, we see how great a difference there is between then and now.

There are two reasons which account for these changes in engineering curricula, one of which is very well expressed in the following quotation from the conclusion to the preliminary report of the Committee on Economic Content of Engineering Education made to the Society for the Promotion of Engineering Education at its recent meeting at Iowa City.

> To those who have had to do with the financing, building, operation, and management of great engineering works of all kinds, it is obvious that the economic problems are of such importance that the man who cannot solve them will always remain a "hewer of wood and a drawer of water."
>
> To those who have been many years in teaching it is equally obvious that the college cannot expect or hope to put in the curriculum all of the subjects that the graduate may or will use in his career after leaving college.
>
> It becomes a question then of determination as to what are *fundamental subjects*, and of excluding those things that are not now essential in order that room may be found for those which have become so.
>
> Recently the Dean of one of the large schools of Business Administration defined engineering as "applied economics." Whether one agrees with the definition or not, one cannot avoid the conclusion that a knowledge of economic theory, accounting, and statistical analysis are absolutely essential in modern business, and that if the engineer is to be a leader in modern business he must possess this knowledge.
>
> It would seem to be perfectly obvious that the curriculum in engineering which does not include these courses is deficient.

Discussion is challenged on a number of questions. One of these is—

> Shall we frankly recognize the tremendous changes which have been taking place in industry in the last twenty-five years, and the place which the engineer occupies in industry, and make our basic training such as is required to fit men for business rather than for scientific research or for technical engineering work, leaving to the Graduate School such specialized training?

O. D. Foster in the June 15, 1926, issue of *Forbes' Magazine* has tried to collect the opinions of leading men in the industries on the value of engineering education to business executives. Gerard Swope, President of the General Electric Company, has this to say:

> If we divide our problems into successive steps as an engineer would do, conditions are immediately clarified. An engineer studies the object to be achieved, analyzes his materials, and then determines how they can be used most economically and to the best advantage. Most problems may be divided into three parts, generally speaking: first, a correct analysis and the drawing of conclusions as to the right course of action; second the decision as to the most advantageous manner of carrying it out; third, the independence and courage necessary to follow the outlined course.
>
> One of the most important needs of today is that men with engineering training grapple with the problems of factory management, especially from the standpoint of relations between management and labor. It is essential in this connection that the man have not only an engineering training, but that he should have a broader outlook so that he may have some idea of the development of human movements and look with understanding and sympathy to the aspirations of labor.

Matthew Brush, President of the American International Corporation, views the value of an engineering education from another angle. He says:

> You cannot know men until you work side by side with them. If I never got another thing but that out of my engineering training it would have been well worth while. A man may have all the administrative ability in the world and may be a past master of organization, but if he does not really understand the men under him he will never get anywhere.
>
> Business is not made up of financial units, but of men. Labor is not a commodity in which we traffic, but it constitutes that great human side which is the biggest part of any organization. And do not forget when you are dealing with men that they have a spiritual as well as a material side.
>
> Outside of what he learns about men through his shop work, an executive uses his engineering training daily in a dozen ways. In my case, although it is years since I have worked out a mathematical problem or swung a hammer, I am always acutely conscious of the value of my engineering training. Take as one instance the purchase of engineering material for the companies with which I am associated. I have a practical knowledge of values and of what we need which I could never have acquired without technical training. It also makes a man more direct and more concise. It gives him not merely a desire but a method on which to build. In other words, it teaches him not merely to build, but how to build.

However, a note of caution is sounded by Alfred P. Sloan, President of General Motors:

> There is one characteristic we engineers have to fight in ourselves, and that is the natural scientific desire to treat the problem from the technical side. It is here the executive should dissociate himself from his engineering training. The engineering mind has the angle of offering something for sale along certain designated lines, whereas the executive must act as a judge who visualizes the plan in its entirety and includes outside matters and their effect on his decision. In other words, he must get away from his thought of it as an engineering problem and regard it as a great forward looking movement of which he is a part. It is in the breadth which engineering gives to his vision that the executive finds one of his most valuable assets.

A College of Imperial Defense for Great Britain

ANSWERING a question on June 16 in the House of Lords, the Earl of Balfour stated on behalf of the Government that a scheme for establishing a College of Imperial Defense was in process of completion. While no information has been given out officially, it is known that the scheme contemplates sending to the College a few senior officers from each branch of the services in order to give them an opportunity to learn methods of coöperation with the other services, thus insuring a closer unity of plan and operation between the Army, Navy, and Air Services. The crux of the matter is, of course, the coöperation between the older branches of national defense and the Air Service, a matter of very considerable difficulty for obvious reasons, but one which at least in England is considered to be of supreme importance because of great and rapid progress in the development of aircraft as a military force, and on the other hand, an unquenchable tendency on the part of the senior officers in the Army and Navy to disregard this very progress in the younger arm.

The editor of *The Aeroplane* (June 23, 1926) cites an instance of the World War, when the Navy never did realize that gun spotting could be done far more accurately by its own aircraft than it could by any method that naval personnel could possibly employ. During Admiral Bacon's bombardment of the Belgian Coast the Navy insisted on taking their spotting from one of their men posted on a church tower at Nieuport. From that point he could see whether the shells were short or over the target, but he could not tell whether the line was correct or not, and all the while the ships refused to take any advice whatever from airplanes which were circulating directly over the target and could give both line and length.

The British Government realized apparently that such a condition of affairs could not be corrected by an executive order, and yet was much too dangerous to be tolerated. Hence the idea of sending the senior officers of the services back to school, even though the latter be dignified by the high-sounding title of College of Imperial Defense.

The same writer makes a significant remark on the extent to which even now quite senior officers in the Navy are beginning to realize that airplanes cannot only fly and report the movements of ships, but must also be considered as serious weapons of offense with bombs and torpedoes. This statement applies, of course, to the British Navy only.

Pacific Coast Holds Enthusiastic Spring Meeting

San Francisco Extends Warm Welcome to A.S.M.E. Visitors and Entertains Splendidly in Meeting Made Memorable by Excellent Program of Sessions and Excursions—Highest A.S.M.E. Award Bestowed on Dr. R. A. Millikan

THE San Francisco Spring Meeting of The American Society of Mechanical Engineers was a highly successful gathering of members of the Society from all sections of the United States. The four days from June 28 through July 1 were taken up with an excellently planned and conducted program of interesting events which included the award of the A.S.M.E. Medal to Dr. R. A. Millikan, an important business meeting at which two amendments to the Constitution were presented, five excellent technical sessions, and an interesting list of excursions and entertainment events.

Each Pacific Coast Section was well represented at the Meeting. The East sent a large delegation by special train, bringing the total registered attendance to 547 and making it the largest meeting of the Society ever held on the Pacific Coast. The San Francisco Section is to be heartily congratulated on the splendid success of its efforts.

The outstanding event on the program was the award of the A.S.M.E. Medal to Dr. Robert Andrews Millikan. This was made on Wednesday evening, June 30, following the dinner at the Palace Hotel. President Abbott called for order at the close of an excellent repast and introduced Warren H. McBryde, Chairman of the San Francisco Section and Chairman of the Local Committee of Arrangements, who acted as master of ceremonies. Past-President Ira N. Hollis, Chairman of the Committee on Awards, and Past-President William F. Durand presented Dr. Millikan to President Abbott for his award. Dr. Durand made the presentation address in which he outlined the achievements of the medalist as a scientist and engineer. President Abbott bestowed the A.S.M.E. Medal, the highest award of the Society, with a simple statement, to which Dr. Millikan responded in equally simple terms expressing his heartfelt appreciation of the honor.

Following introductory remarks by Mr. McBryde, Dr. Millikan addressed the gathering on Atomic Mechanics. In the first part of his address Dr. Millikan visualized the modern Samson seeking to destroy the temple of modern civilization by pushing down its most important supporting pillar. This destructive Samson would find the supporting pillar in the field of modern science which, if swept out, would remove the element which sustains modern civilization. In science, however, he said, the representative group of ideas underlying modern civilization are not found in medicine, electricity, or chemistry, but in the dynamic laws of Newton and Galileo. Newton formulated the rules based on the experiments of Galileo which make possible this new era of machinery. The application of these laws made first to terrestrial mechanics about a century and a half ago has only within the last century been made to machine design and construction, and in them we have the heritage of the mechanical engineer.

Dr. Millikan then traced the tremendous advances in the technique of engineering and science during the past twenty-five years. He stated that the laws of conservation of chemical elements, of conservation of mass and energy, and the laws of motion and of electrodynamics, which were recorded as fixed and immutable in 1900 could not now be applied in their entirety. The tendency to generalize too far from the facts on which these laws were based had made them useless as guides to scientific technique. Doctor Millikan explained how in his work in isolating and measuring the electron, for which he was awarded the Nobel Prize, even the laws of Newton were not applicable, but that the facts and observations on which these laws were based were as true today as they were when Newton stated them.

Dr. Millikan's address, delivered with the intensity of the enthusiast in science, held his hearers spellbound for nearly an hour.

The second speaker of the evening was William Sproule, President of the Southern Pacific Company, who opened his remarks with a statement of deep appreciation for Dr. Millikan and his conception of the infinite and the infinitesimal. Mr. Sproule extended a welcome to San Francisco and the Pacific Coast, and expressed pleasure that the meeting of the Society was held in San Francisco. He pointed out the importance of such meetings, as progress depends upon the attrition of minds. He emphasized the responsibility of the mechanical engineer in the advancement of industry and civilization, working with a well-ordered mind, imaginative but under control. In his remarks, however, he stressed the importance of greater understanding of economic values by engineers.

Council Meeting

THE Council Meeting was held Monday morning, June 28, at the Palace Hotel. President W. L. Abbott presided and the following were present:

Past-Presidents James Hartness, John R. Freeman, Dexter S. Kimball, and William F. Durand;

Vice-Presidents Robert W. Angus, Sherwood F. Jeter, and Roy V. Wright;

Managers E. O. Eastwood, E. R. Fish, Edward A. Muller, Robert L. Daugherty, William Elmer, and Charles E. Gorton;

Erik Oberg, Treasurer, Calvin W. Rice, Secretary, C. N. Lauer, Chairman Committee on Meetings and Program, Paul Doty, Local Sections Committee, Ira N. Hollis, Chairman Committee on Awards, and John T. Faig, Chairman Committee on Education and Training.

Announcement was made of a gift of twenty-five thousand dollars by John R. Freeman. This gift is one of three similar amounts given to the Boston Society of Civil Engineers, the Americon Society of Civil Engineers, and The American Society of Mechanical Engineers. A committee was appointed to prepare a statement of the ways and means by which the income from the fund should be expended.

The principal business was the selection of Kansas City as the place for a Regional Meeting during April, 1927, and White Sulphur Springs for the Spring Meeting during May, 1927.

The Council approved the recommendation of the Oil and Gas Power Division that the Society participate in the Oil Power National Conference to be held during the week of April 18–23, 1927.

The Council voted to make a contribution to the fund to enable the Society for the Promotion of Engineering Education to complete the research in engineering education which is now being conducted.

The American Engineering Council reported with regret the resignation of E. J. Prindle as a member and chairman of the Patents Committee. Mr. Prindle has served for a long time with notable success as chairman of this important committee as a representative of the A.S.M.E. The Council approved the nomination of Elmer A. Sperry as the successor of Mr. Prindle on the Patents Committee.

Secretary Rice made a report on his visit to Europe as a representative of the Museums of the Peaceful Arts of New York, during which he called on representatives of Engineering Societies throughout Europe and carried out a number of missions of immediate import to the American engineering profession. During the trip he was the guest at a dinner of the Council of the Institution of Mechanical Engineers in London and at a luncheon given by the Board of the Verein Deutscher Ingenieure in Berlin. At Prague he was the guest at a luncheon given by the Secretary of Commerce of Czechoslovakia to meet the officers of the Masaryk Academy. At Vienna he attended a special luncheon given by the Austrian Society of Engineers and Architects.

During his trip Secretary Rice was the recipient of several distinctive honors. The Honorary Degree of Doctor of Engineering was bestowed by the Technical High School at Darmstadt, the State of Bavaria presented him with the Golden Ring of Honor, and he was elected an Honorary Member of the Deutsches Museum.

He reported that on May 31 in Paris there was an enthusiastic meeting of the members of the four American Founder Societies

at which it was decided to organize the American engineers resident in France in permanent form. Besides Mr. Rice, Past-President Jesse M. Smith and two honorary members, Messrs. de Freminville and Rateau, were present, as well as the secretary and other officers of the American Institute of Mining and Metallurgical Engineers. In Paris, he discussed with French educational authorities the problem of French exchange professorships with the United States. He also made tentative plans with two French universities for placing a few French technical graduates in American industry.

Business Meeting

THE Spring Meeting was officially opened at eleven o'clock on Monday, June 28, when President W. L. Abbott called the Business Meeting to order in the Palace Hotel.

The most important matter on the order of business was the Report of the Committee on Constitution and By-Laws recommending amendments to the Constitution. These amendments, designed to make the treasurer an officer appointed by Council, to increase the number of vice-presidents from six to seven, and to increase the maximum age at which an individual may still continue to be a Junior Member from thirty to thirty-five, were read to those present. After motions duly made and seconded, the amendments were ordered submitted to the membership for action by letter-ballot. They read as follows, the old wording, which will be deleted if the amendments are adopted, being set in italics, and the new wording which will be added, being all set in capitals:

ARTICLE C5, JUNIOR MEMBERSHIP

Sec. 6. A Junior must have had such engineering experience as will enable him to fill a subordinate position in engineering work, or he must be a graduate of an engineering school of accepted standing. He must be at least twenty-one (21) years of age, and his connection with the Society shall cease when be becomes *thirty (30)* THIRTY-FIVE (35) years of age unless he *be* HAS BEEN previously transferred to another grade.

ARTICLE C7, DIRECTORS AND OFFICERS (COUNCIL)

Sec. 1. No change.

Sec. 2. The Directors of the Society shall consist of a President *six (6)* SEVEN (7) Vice-Presidents, nine (9) Managers, AND the last five (5) surviving Past-Presidents *and a Treasurer.*

Sec. 3. No change.

Sec. 4. The President shall be elected for one (1) year, the Vice-Presidents for two (2) years, the Managers for three (3) years *and the Treasurer for one (1) year.*

Sec. 5. No change.

Sec. 6. (New Sec. 6 renumbering present Sec. 6 to Sec. 7.)

Sec. 6. AT ITS FIRST MEETING AFTER THE ANNUAL MEETING OF THE SOCIETY THE COUNCIL SHALL APPOINT A MEMBER OF THE SOCIETY TO SERVE AS TREASURER FOR ONE (1) YEAR.

THE TREASURER SHALL PERFORM THE DUTIES USUALLY PERTAINING TO HIS OFFICE, IN ACCORDANCE WITH THE BY-LAWS AND RULES, AND SUCH FURTHER DUTIES AS MAY BE REQUIRED BY THE COUNCIL.

ANY VACANCY IN THE OFFICE OF TREASURER SHALL BE FILLED BY APPOINTMENT BY THE COUNCIL.

Sec. 7. (Same as old Sec. 6.)

As this was the first Business Session of the Society to be held on the Pacific Coast in thirty-four years, it afforded an excellent opportunity for the members residing west of the Rockies to discuss ways and means whereby the organization of the Society may be made more helpful to such of them as are remote from the larger centers of membership. A number of splendid suggestions were received which will be formulated more carefully and presented for action to the proper committees of the Society.

Announcement was made that the 1927 Spring Meeting will be held in White Sulphur Springs, W. Va. This will be the first meeting of the Society in a number of years to be held at a resort where the individual members may have an opportunity to become acquainted in an atmosphere of mountains and golf. Petition for the meeting was presented by the West Virginia Section of the Society, with the endorsement of the Committees on Local Sections and Meetings and Program and with the unanimous support of the Local Sections Delegates who met in December, 1925. The Society is therefore looking forward with a great deal of pleasure to a very successful gathering at White Sulphur Springs during the latter part of May, 1927.

As one of the steps in the procedure of adopting standards, the following were presented by title: Small Rivets; Tinners', Coopers' and Belt Rivets; Wrench-Head Bolts and Nuts; Track Bolts; Round Unslotted Head Bolts; Plow Bolts; T-slots and Parts; Gib-Head Taper Keys; Plain Taper Keys; Spur-Gear Tooth Form; Steel Pipe Flanges and Flanged Fittings; and Methods of Gaging and Specifications for Plain Limit Gages. These Standards, which had previously been submitted in draft form for revision and had been adopted by Council, are now, after presentation at a public meeting of the Society, ready for acceptance as American Standards.

Entertainment Events

THE entertainment events at the Meeting gave every one a splendid opportunity to become acquainted. The opening entertainment was the informal reception on Monday evening, which was followed by dancing. The San Francisco Committee introduced one novelty at this event when they presented a Chinese giant eight feet four inches tall.

The dinner on Wednesday evening has been mentioned earlier in this account. A splendid program was prepared for the ladies to supplement the regular program of entertainment and excursions in which they participated. Trips through the shopping district and Chinatown furnished a great deal of enjoyment, and large amounts of drygoods and souvenirs were brought away from San Francisco by the ladies from the East.

The excursions were planned to give to the visitors a thorough understanding of the scenic and industrial resources of the San Francisco district. Monday afternoon over two hundred journeyed by steamer and special train to Mt. Tamalpais and the Muir Woods where they reveled in a view of the Golden Gate and the ranges of mountains surrounding San Francisco, and saw some of the large trees. On Tuesday, June 29, there was a trip by special steamer around San Francisco Bay. This trip gave opportunity to view the drydock of the Bethlehem Shipbuilding Corp. at Hunter's Point, the entire San Francisco water front, the Golden Gate, Raccoon Straits, Mare Island Navy Yard, finally docking at the plant of the California & Hawaiian Sugar Refining Corp. at Crockett. Excellent arrangements were made for conducting the party through the plant, and at the close of the inspection trip visitors were the guests of the Corporation at an excellent dinner. The return trip to San Francisco was made by moonlight, dancing being enjoyed on deck.

On Wednesday afternoon a party embarked on an extensive auto trip around San Francisco. The tour included the water front, the Presidio, Golden Gate, Lincoln Park, the Cliff House, Golden Gate Park, and Twin Peaks, from which a magnificent panorama of the city was visible. From Twin Peaks the tour viewed the Mission Dolores and the Civic Center on the way to the Fairmount Hotel, where tea was served to the ladies.

On Thursday there was an all-day trip to the East Bay district. Special launches conveyed the party across the Bay and up the Oakland Estuary, landing at Oakland at noon. At this point the party split, one group having luncheon at Oakland and viewing Oakland and the University of California by automobile. The second group was taken to the plant of the Caterpillar Tractor Company at San Leandro, where luncheon was served. Following luncheon an interesting series of motion pictures showing caterpillar tractors in action was shown, and then the entire party was conducted through the factory.

On Thursday afternoon a large number of visitors went to Leland Stanford University by automobile, where they inspected the campus.

One of the interesting excursion features was an exhibit of the three-cylinder locomotive by the Southern Pacific Railway at its station at Third and Townsend Streets. This locomotive, designed for heavy passenger and fast freight service over heavy grades, has a total weight of 316,000 lb. and a tractive effort of 96,520 lb., and operates at a boiler pressure of 255 lb. per sq. in.

In addition to the scheduled trips, twenty-five industrial plants of San Francisco and vicinity threw open their doors to the visitors during the Meeting, and guides were provided and a great many individuals afforded themselves of this excellent opportunity to become acquainted with the industrial facilities of the city.

Those Who Made the San Francisco Meeting a Success

SPRING MEETING COMMITTEES

Executive

Warren H. McBryde, *Chairman*
Frederick Birdsall, *Secretary*
C. M. Gunn, *Treasurer*

E. M. Breed
E. B. Bumsted
A. J. Dickie
Ely C. Hutchinson
J. A. Kinkead
Bruce Lloyd
Elgin Stoddard
H. L. Terwilliger

Technical Events

E. C. Hutchinson, *Chairman*
C. H. Delany
H. C. Bills
R. L. Mahon

Finance

C. M. Gunn, *Chairman*
F. T. Letchfield
E. O. Shreve

Hotel

E. B. Bumsted, *Chairman*
C. G. Cox
R. A. Hudson

Reception

Elgin Stoddard, *Chairman*
Dale Bumsted
G. C. Cox
David Dorward, Jr.
D. M. Green
L. F. Halloran
W. W. Hanscom
C. T. Henderson
L. G. Henes
V. W. Hoxie
C. T. Hutchinson
J. N. LeConte
W. E. Leland
E. W. Lindquist
C. M. Mardel
F. W. Mahl
Wynn Meredith
T. B. Paulson
Robert Sibley
C. H. Smith
H. W. Stebbins
A. J. Turner
J. T. Whittlesey

Entertainment

W. H. McBryde, *Chairman*
G. A. Armes
E. B. Bumsted
G. L. Hurst
J. C. Martin
Robert Sibley
H. L. Terwilliger
A. J. Turner

Publicity

A. J. Dickie, *Chairman*
Carleton French
W. M. Moody
A. A. Tacchella

Printing and Signs

E. M. Breed, *Chairman*
L. S. King
R. S. Quick

Ladies' Entertainment

H. L. Terwilliger, *Chairman*
Dennistoun Wood
G. L. Hurst

Ladies' Reception

Mrs. E. M. Breed
Mrs. E. B. Bumsted
Mrs. W. R. Eckart
Mrs. C. M. Gunn
Mrs. G. L. Hurst
Mrs. C. T. Hutchinson
Mrs. Ely C. Hutchinson
Mrs. E. P. Lesley
Mrs. Warren H. McBryde
Mrs. Robert Sibley
Mrs. H. W. Stebbins
Mrs. H. L. Terwilliger
Mrs. A. J. Turner
Mrs. Dennistoun Wood

Information and Registration

J. A. Kinkead, *Chairman*
H. H. Anderson
Leonard Cahoon
C. N. Cross
A. B. Domonoske
A. L. Gossman
W. A. S. Harmon
F. J. Hearty
R. L. Hemingway
A. C. Lang
H. B. Langille
M. D. McPartland
W. L. Newell
T. W. Selser
H. W. Stebbins
C. W. Tubby
G. S. Wilson

Excursions

Bruce Lloyd, *Chairman*

H. C. Bills
A. J. Dickie
A. M. Duperu
Carleton French
R. A. Hudson
H. P. Phillips

A.S.M.E. Special Tour

One of the factors contributing to the success of the San Francisco Meeting was the large delegation of those who came from east of the Mississippi River by special train to attend it. About 110 members of the Society and their friends left New York on June 14. At Chicago 53 joined the party, and a train of 14 cars made its way westward, stopping at Kansas City, Denver, Colorado Springs, Santa Fe, Albuquerque, Grand Canyon, San Bernardino, Riverside, Los Angeles, and Yosemite Valley en route to San Francisco.

At Kansas City, Denver, and Los Angeles special arrangements had been made by the A.S.M.E. Local Sections for entertainment, and the special tour received a hearty welcome. At Santa Fe and at Albuquerque the Chambers of Commerce turned out in force with their automobiles to conduct the visitors around their cities.

At the close of the Meeting on July 1, the party returned east, stopping at Portland, Mt. Rainier, Seattle, Victoria, Vancouver, and Revelstoke, at which latter place the train was delayed by a landslide. Officials of the Canadian Pacific Railway and the citizens of Revelstoke prepared a program of entertainment which was so thoroughly enjoyed that those on the special train felt that the stay there was one of the happiest of the trip. After the right of way was cleared the party proceeded, stopping at Lake Louise, Banff, Minneapolis, St. Paul, and Niagara Falls, although their sojourn at these points was somewhat shortened in order to permit the train to reach New York on July 13 as scheduled.

On the return trip the party received many special attentions from Local Sections organizations at Portland and Seattle, and from the Mayor at Vancouver.

This special tour will be described more fully in the August 7 issue of the *A.S.M.E. News*.

Technical Sessions

At the five technical sessions, which were well attended, discussion was thorough and the interest well sustained. The papers, which were designed to bring out the matters of interest to mechanical engineers on the Pacific Coast, reflected the latest experience of the membership. The interest in the sessions is the direct outcome of the complete printing of the papers well in advance of the meeting for issue to those who desired to participate in the discussion.

Petroleum Session

W. R. Eckart, professor of mechanical engineering at Leland Stanford University and chairman of the A.S.M.E. Petroleum Division, presided at the Petroleum Session held Tuesday morning, June 29, in the Palace Hotel. The first paper was that of D. H. Atherton, on Fluid Flow in Pipes of Annular Cross-Section. There were four discussions on this paper: one by Lewis F. Moody in written form which was read by H. H. Blee; one by W. R. Eckart in written form; and oral discussions by C. F. Wieland and Sanford A. Moss. In the second paper B. N. Broido dealt with Mechanical Engineering in the Cracking, Heating, and Cooling of Oil. This paper was presented by F. J. Hearty, and was discussed orally by N. W. Thompson. The third paper, by F. L. Kallam, was entitled The Termination of Charcoal Tests. G. V. D. Marks presented this paper in the absence of the author, and it was discussed by A. F. Semino, J. H. S. Bates, and Mr. Marks. The papers by Messrs. Atherton and Kallam appeared in pamphlet form previous to the meeting, and that by Mr. Broido was printed in the supplement to the June issue of Mechanical Engineering.

Session on Industrial Training and Education

The Session on Educational and Training for the Industries was held Tuesday morning, June 29, in the Palace Hotel. Frank B. Drake, president of the Johnson Gear Co., San Francisco, presided over the presentation and discussion of the two papers. John L. Kerchen presented a paper on The Growth of University Extension Training of the Non-College Type for the Industries of the West, and Paul Eliel one on Education and Training of Apprentices on the Pacific Coast. These two papers were discussed orally by L. D. Burlingame, E. H. Neff, S. S. Jacobs, Geo. H. Shepard, John Parker, John T. Faig, H. L. Pierce, Benj. E. Mallory, and H. C. Bills. A written discussion was contributed by C. W. Cross and read by Mr. Bills. The papers presented at this session appeared in the supplement to the June Mechanical Engineering.

Fuel and Railroad Session

On Wednesday morning, June 30, the Fuel and Railroad Session was held in the Palace Hotel, with C. L. Cory, dean of the College of Mechanics, University of California, in the chair. H. T. Woodward, of Los Angeles, presented a paper prepared by J. Grady

Rollow on Combined Oil- and Gas-Burning Furnaces for Power-Plant Use. This paper was discussed by C. H. Delany, C. R. Weymouth, and Max Toltz, all of whom pointed to the importance of further information on the burning of oil. The second paper, on Fuel Oil for Railways, was presented by the author, J. C. Martin, Jr. Henry S. Knauer presented written discussion, and the paper was then discussed orally by J. C. Clark, Dennistoun Wood, Frank E. Russell, Max Toltz, and E. J. Staples. The final paper of the morning dealt with the development of the Caterpillar Tractor and Its Application to Industry. In the absence of the author, Pliny E. Holt, the presentation was made by F. L. Peterson, who illustrated it with a series of interesting moving pictures. The discussion consisted in answering a number of questions from the floor regarding the design and operation of the caterpillar tractor. Later a written discussion was received from Robert Sibley, who pointed out the importance of the contribution of western engineers in the design of the tractor as a factor in the advancement of agriculture. All the papers presented at this session appeared in the supplement to the June issue of MECHANICAL ENGINEERING.

HYDRAULIC SESSION

H. L. Doolittle, assistant construction engineer of the Southern California Edison Co., presided over the presentation of the three papers at the Hydraulic Session held Wednesday morning, June 30, in the Palace Hotel. A. H. Markwart presented his paper on Aspects of Steam Power in Relation to a Hydro Supply, and Ross Mann read one by H. A. Barre on Water Power and Steam Power in California Utilities. These two papers were discussed together, and R. L. Thomas cited a number of factors in favor of the full development of all of the possibilities of a water-power site. He made the suggestion that steam plants should be considered as stand-bys for transmission lines rather than for hydroelectric plants. S. A. Moss presented data showing the relation between industrial development and demands for the construction of steam plants as a part of eastern hydroelectric systems. He pointed out that under certain conditions the installation of units of from 5000 to 16,000 kva. was practical. President Abbott, speaking from his experience in the Middle West, pointed out that sometimes it was cheaper to carry fuel to a centrally located steam plant than to pay transmission-line costs. This statement brought out the fact that a transmission line through a territory served as a nucleus for public service, which the handling of fuel over a railroad did not give. The final paper of the morning was that of E. B. Strowger and S. Logan Kerr, on Speed Changes of Hydraulic Turbines for Sudden Changes of Load. It was presented by Ray S. Quick and was discussed in written form by E. E. Halmos, O. V. Kruse, and W. F. Uhl, and orally by Roy Wilkins and Mr. Quick. Mr. Barre's paper was printed in the supplement to the June issue of MECHANICAL ENGINEERING. The other papers were preprinted in pamphlet form.

OIL AND GAS POWER SESSION

The session on Oil and Gas Power held Wednesday morning, June 30, was presided over by J. H. Hansen, president of the Pacific Diesel Engine Co. Prof. A. B. Domonoske of Leland Stanford University presented the first paper, written by A. I. Lipetz, on Transmission of Power on Oil-Engine Locomotives. This complete treatise on the subject was discussed in written form by Elmer A. Sperry, R. Eksergian, and C. A. Norman, while John Parker, A. Hollander, and William Elmer offered oral comments. The second paper of the morning, on Oil Engines as a Drive for Pipe-Line Pumps, written by F. Thilenius, was presented by C. G. A. Rosen, and discussed orally by A. Hollander and J. H. Hansen. The final paper of the morning, by C. W. Cutler, dealt with Uniform Methods of Calculating the Periodic Displacement and Oscillations in Synchronous Machines, and was presented by J. M. Dodds. A written discussion submitted by H. C. Lehn was read by R. Menges. Mr. Hansen presented an oral discussion.

Conference on A.S.M.E. Boiler Code

ON THURSDAY morning, July 1, members of the California Industrial Accident Commission's Advisory Committees on Revision of Air Pressure Tank Safety Orders met with several members of the A.S.M.E. Boiler Code Committee and a number of interested guests in an informal discussion of Section VIII of the A.S.M.E. Boiler Construction Code which consists of rules for the construction of unfired pressure vessels.

E. G. Sheibley, Chief Engineer of the Department of Safety of the California Industrial Accident Commission, presided, and G. O. Wilson acted as secretary. The Boiler Code Committee was represented by E. R. Fish, C. E. Gorton, Dr. W. F. Durand, S. F. Jeter, and C. W. Obert, Secretary of the Committee. Representatives of the oil industry, of insurance companies, and of manufacturers and users of pressure vessels discussed the Code and such related subjects as methods of enforcing the Code, its application to vessels other than air tanks, and the technique of welding.

At the close of the meeting Mr. Sheibley announced that later on the committees which are at work revising the California Safety Orders would meet for further discussion at both San Francisco and Los Angeles before publishing the rules that are to be presented for public hearing.

The meeting was regarded by all concerned as affording an excellent opportunity to obtain the intimate understanding of the Boiler Construction Code which is necessary to secure the application of its various sections to industrial conditions.

Thirty-Four Years Ago

IT WAS just thirty-four years ago that the first excursion to an A.S.M.E. meeting in San Francisco took place at the suggestion of C. W. Hunt, who saw in this event an opportunity to extend the national scope of the Society, as the trip to Europe in 1889 had brought to it international attention, and to stimulate professional interests on the Pacific Slope. Interesting parallels between this and the 1926 meeting are brought to mind by a perusal of the accounts given in volume 13 of Transactions.

The 1892 excursion, which left New York on May 4, followed much the same route as this year's trip as far as Denver, where, instead of going south through Santa Fe and the Grand Canyon to Los Angeles, it continued west through Salt Lake City and Ogden to Sacramento and Monterey.

W. R. Eckart, father of Professor Eckart—who will be remembered by members at the 1926 convention—was chairman of the local committee in 1892, and W. E. Schoenborn, of Washington, D. C., was a member of both parties.

The non-technical features of the 1892 convention were not very different in nature from those of this year's convention. In 1892 the Spreckels tug *Fearless* took the members on the excursion on San Francisco Bay; and Mare Island Navy Yard, the Union Iron Works, Pelton Water Wheel Shops, Pacific Rolling Mill, Sutro Heights—then the residence of Mr. Adolph Sutro—Golden Gate Park, with a different Cliff House but the same Seal Rocks, appear on both programs of events. The cable-railway systems, which excited so much interest in 1892, and the carriages, have given place to more modern methods of transportation. It was to the Palace Hotel that both parties came at the end of their westward trips—different buildings, of course, but the same site.

The technical sessions of the two meetings were strikingly different. Nothing was said of hydroelectric plants in 1892, nor of oil engines; but steam engines, their governing, economy, and design, were widely discussed. A paper on the utilization of power of ocean waves indicate the persistence with which such subjects harass the minds of engineers, and a paper on boiler testing shows the unfailing interest in this line. It was at this meeting that Dr. Goss described the locomotive testing plant at Purdue and that Harris Tabor discussed machine molding; and one also sees the familiar names of G. I. Alden, A. F. Nagle, C. H. Peabody, W. O. Webber, F. M. Rites, F. A. Scheffler, D. S. Jacobus, and J. E. Denton.

In 1892 the party broke up at San Francisco and divided into four sections. One was a straight run back with no side trips. A second took the southern route through Los Angeles, Arizona, New Mexico, Colorado, and Kansas to Kansas City. The third party took a side trip through the Yosemite Valley, and back to San Francisco, leaving again for Portland, Oregon, and returning east through the Yellowstone. The fourth party sailed from Tacoma for Alaska on the *Queen*, returning in thirteen days and traveling to New York via the Yellowstone.

Book Reviews and Library Notes

THE Library is a coöperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E. and the A.I.E.E. It is administered by the United Engineering Society as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Economic America

Das Wirtschaftliche Amerika. By Carl Köttgen. V.D.I. Verlag, Berlin, 1925. Cloth, 6 × 8 in., 182 pp. and 40 illustrations.

THE purpose of this dissertation is to examine in some detail the economic factors upon which the industrial life of the United States is based, and then to compare the picture thus developed with the conditions at present existing in Germany, mainly with a view of determining whether these conditions are susceptible of adaptation to American standards.

The work is naturally written for the benefit of German readers. American readers may get virtually all the statistics quoted for home conditions in the publications of the National Industrial Conference Board, and the volume is therefore of special interest only to those Americans who desire information on comparative conditions as between Germany and this country.

Köttgen takes up in order the distribution of labor among the principal industries in each country, the relative output of labor, the relative wages, relative cost of living, etc., and shows finally that the difference in the industrial conditions in the two countries is largely founded in the much more extended use of labor-saving machines, as a substitute for human labor, in the United States as compared with Germany. He points out, of course, that the incentive to the use of labor-saving machinery in the United States is much stronger than it is in any other country on the globe, because of the relatively high wages. Thus while wages in the United States are three times as high as compared with Germany, the cost of living is only about double, as a direct effect of the extended use of such machines.

Köttgen uses several American plants as illustrations of his thesis, notably the Ford plant and that of the Plimpton Press. He closes with a brief but comprehensive survey of some special features affecting industrial life in this country: immigration, prohibition (which, by the way, he approves as far as making labor more effective is concerned), education, mail-order houses, installment buying, etc. He touches upon the work of the National Industrial Conference Board, and upon that of the Department of Commerce as far as it concerns standardization, waste prevention, specifications, etc. He seems in general to be favorably impressed with these activities, and bespeaks for them greater attention in the part of German authorities, but points out that as far as old-age insurance, compensation insurance, sick benefits, and similar government activities are concerned, the United States is not in a leading position.

H. Diederichs.[1]

Books Received in the Library

Divergente und Konvergente Turbulente Stromungen mit Kleinen Öffnungswinkeln. By Fritz Dönch. V.D.I. Verlag, Berlin, 1926. (Forschungsarbeiten auf dem Gebiete des Ingenieurwesens. Heft 282.) Paper, 7 × 10 in., 58 pp., diagrams, tables, 7.50 r.mk.

This brochure presents the results of another of the series of investigations of fundamental problems in the flow of fluids which are being carried on at the Institute of Applied Mechanics in Göttingen, under Professor Prandtl's direction. Using air and a rectangular pipe with movable walls, the investigator examined the details of turbulent flow, especially convergent and divergent flow, from a unified point of view. Formulas are derived and the experimental results are evaluated.

Die Edelstähle, Ihre Metallurgische Grundlagen. By F. Rapatz. Julius Springer, Berlin, 1925. Boards, 5 × 8 in., 219 pp., illus., diagrams, tables, 12 r.mk.

This book aims to be an introduction to the study of alloy steels. The author has especially intended to show what properties are necessary for various purposes and what properties the steels now in use have. After a brief introduction, the author discusses the uses of alloy steels and the demands made of them, the qualities that make for easy working, structure, and heat treatment. The various steels are described and the method of manufacture explained. Methods of testing and imperfections are discussed.

Elementary Treatise on Statically Indeterminate Stresses. By John Ira Parcel and George Alfred Maney. John Wiley & Sons, New York, 1926. Cloth, 6 × 9 in., 368 pp., diagrams, tables, $5.

Aims to present the fundamental methods of attack on the problem of indeterminate stresses as clearly as possible and as fully as is consistent with an elementary treatise, and to illustrate the methods by applying them to some common types of indeterminate structures. The first three chapters, comprising more than one-third of the book, give an exposition of the theory of elastic deflections and a broad treatment of the general problem of indeterminate stresses. Chapters four to seven treat specifically the continuous girder, the rigid frame, the elastic arch, and secondary stresses. The final chapter contains a general discussion of statically indeterminate construction, a historical review, and a good annotated bibliography.

Feuerversicherung und Brandschadenabschätzung bei Maschinellen Fabrikeinrichtungen. By Felix Moral. V.D.I. Verlag, Berlin, 1926. Paper, 6 × 8 in., 102 pp., 2.80 r.mk. (3.80 r.mk. bound).

A concise practical handbook on factory insurance. The author discusses under-insurance and over-insurance, the various kinds of insurance of plant equipment, special clauses for equipment insurance, the appraisal of machinery for insurance and the form of the policy. He also treats of expert appraisal of fire losses and of the determination of damages to machinery by fires.

Fuel Oil Viscosity-Temperature Diagram. By Guysbert B. Vroom. Simmons-Boardman Publishing Co., New York, 1926. Chart, 14 × 11 in., $3.

The viscosity curves of fuel oils, plotted to a double logarithmic scale, become straight lines which pass through a common point on the diagram. This point has been determined by experiment. It can be used as the origin of the curve of any fuel oil and the curve can be found by determining one other point on it.

Lieutenant-Commander Vroom's chart consists of a diagram with a transparent arm pivoted at the common point. If the viscosity of a fuel oil at any one temperature is known, the temperature to which it must be heated to reduce it to any desired viscosity can be read directly from the chart. The diagram shows viscosities on the Saybolt Universal, Saybolt (Furol), Engler, and Kinematic

[1] Director of Sibley School of Mechanical Engineering, Cornell University, Ithaca, N. Y. Mem. A.S.M.E.

scales, those most used in this country. It is substantially mounted for use.

Growth of American Trade Unions, 1880–1923. By Leo Wolman. National Bureau of Economic Research, New York, 1924. Cloth, 6 × 9 in., 170 pp., charts, tables, $3.

A study made under the auspices of the National Bureau of Economic Research. The author shows the changes in the membership of American trade unions during the period under consideration and the relation of that membership to the entire number of wage earners. The author has made a careful compilation and critical study of the statistics, which he presents in tabular form, without giving opinions as to their meaning.

Landeselektrizitätswerke. By A. Schönberg and E. Glunk. R. Oldenbourg, München and Berlin, 1926. Paper, 8 × 11 in., 398 pp., illus., diagrams, maps, 26 mk.

A thorough, important discussion of the problem of centralized production and distribution of electricity, or in other words, of superpower systems. The authors pay but little attention to such matters as hydraulic machinery, generating equipment, etc., but discuss thoroughly and in detail the broad technical, economic, and legal questions involved in unified systems of generation and distribution. The object throughout is to call attention to correct methods for the economic utilization of natural power resources in the most efficient way. The principles enunciated are illustrated by descriptions of various large German undertakings carried out by the firm of Oskar von Miller, of which the authors are technical managers.

Maschinen zum Bedrucken von Textilstoffen, Garndruck, Zeugdruck, Tapetendruck. By Henri Silbermann. Max Jänecke, Leipzig, 1926. Cloth, 6 × 8 in., 198 pp., illus., 13.90 mk.

A review of machinery for printing textiles which has been patented in Germany during the period from 1913 to 1925. The book is a useful description of modern processes, which should interest manufacturers and users of textile machinery.

Metal-Plate Work; Its Patterns and their Geometry. By C. T. Millis. Fifth edition. E. & F. N. Spon, London; Spon & Chamberlain, New York, 1926. Cloth, 5 × 8 in., 503 pp., diagrams, 7s. 6d.

Sets forth a system of geometric construction of the patterns for sheet-metal work which has been in use for over forty years. By it, nearly all the patterns required may be laid out on one geometric principle. The new edition has been rearranged and enlarged.

Physical Chemistry for Colleges. By E. B. Millard. Second edition. McGraw-Hill Book Co., New York, 1926. (International chemical series.) Cloth, 6 × 8 in., 458 pp., diagrams, tables, $3.50.

Aims to bring before the student certain of the more important aspects of physical chemistry, together with accurate data that illustrate the applicability of its laws to the phenomena observed in the laboratory. The new edition has been revised and some portions have been enlarged and rewritten.

Practical Paper-Making. By George Clapperton. Third edition, revised by R. H. Clapperton. Crosby & Son, London; D. Van Nostrand Co., New York, 1926. Cloth, 5 × 7 in., 220 pp., illus., $2.50.

A concise manual for papermakers, in which much practical advice is given on present-day methods. The new edition follows closely the plan of previous ones, but has been changed by omitting obsolete methods and adding new ones, and by the addition of descriptions of new machinery.

Die Schalltechnik. By Richard Berger. Frederick Vieweg & Son, Braunschweig, 1926. Paper, 6 × 9 in., 115 pp., diagrams, 8 r.mk.

A summary of the present state of knowledge of acoustics. The monograph is intended to enable those not deeply informed to orient themselves quickly in this field, and also to point the directions in which research is needed.

Statik für Baugewerkschulen und Baugewerksmeister, vol. 2; Festigkeitslehre. By Karl Zillich. Ninth edition. Boards, 5 × 7 in., 157 pp., diagrams, tables, 3.40 mk.

A concise manual on the strength of structural materials, intended as a textbook and a ready reference book.

Story of the Western Railroads. By Robert Edgar Riegel. Macmillan Co., New York, 1926. Cloth, 5 × 8 in., 345 pp., $2.50.

While there are many books on various phases of the railroad problem and on particular roads and railroad men, there has been practically no attempt, the author of this work says, to combine these into a general history of the railroads. The present book is an attempt to do this for the western roads. The treatment is economic and social and covers the period from 1852 to the early years of the present century when, in the view of the author, the western railroad net was completed. A considerable bibliography is included.

Die Stückzeitberechnung für Holzbearbeitungs-Maschinen. By Oswald Beck. V.D.I. Verlag, Berlin, 1926. Paper, 6 × 9 in., 164 pp., illus., graphs. 8.80 r.mk.

This should interest those engaged in the woodworking industries, as it presents the results of extensive time studies of woodworking machinery. Curves are given showing the cutting speed and piece time for the major woodworking tools under various conditions, for both hard and soft wood.

Supervision of Vocational Education of Less Than College Grade. By J. C. Wright and Charles R. Allen. John Wiley & Sons, New York, 1926. Cloth, 6 × 8 in., 415 pp., $3.

This book, by the director and the editor of the Federal Board for Vocational Education, aims to place at the disposal of prospective and novice supervisors such portions of their own experiences as will assist them to improve their work. The topics discussed include the work of administrators and supervisors, qualifications, preparation, and methods of supervision.

Topographical Drawing Notes. By G. P. Schubert. Second edition. Michigan College of Mines, Houghton, Mich., 1926. Cloth, 6 × 9 in., 82 pp., 11 drawings and diagrams. $1.65.

This textbook supplements the lectures and laboratory work in a course on topographical drawing and traverse computations given at the Michigan College of Mines. It treats various methods of calculating and plotting traverses, and of drawing suitable topographic maps. The course given at this institution is planned to enable surveyors and mining engineers to do as much of this class of work as they may be called upon to do in their regular practice.

Ueber den Martensit. By H. Hanemann and A. Schrader. Verlag Stahleisen, Düsseldorf, 1926. (Mitteilung aus der Metallographischen Abteilung des Eisenhüttenmännischen Laboratoriums der Technischen Hochschule zu Berlin.) Paper, 8 × 11 in., 25 pp., plates, 6.60 mk.

This brochure presents the results of an investigation of martensite undertaken to determine the soundness of a new hypothesis concerning its structure. Martensite, according to this hypothesis, contains two hitherto unknown phases of the iron-carbon alloys, different from alpha and beta iron. The methods of investigation and the results are given, together with a discussion by various experts.

Versuche mit dem Giessverfahren für Eisenbeton. Reported by F. Schmeer. Wilhelm Ernst & Son, Berlin, 1926. (Deutscher Ausschuss für Eisenbeton, heft 55.) Paper, 7 × 10 in., 31 pp., illus., diagrams, 3.90 r.mk.

A detailed report of the results of tests of reinforced concrete structural elements made by pouring or spouting the concrete. The tests were made under the direction of the German Reinforced Concrete Committee and were undertaken to determine whether that method of placing concrete was as safe as older ones. The conclusion is that the method has no unfavorable influence on the strength of the concrete.

Workshop Operations and Lay-Outs for Economic Engineering Production. By Philip Gates. E. & F. N. Spon, London; Spon & Chamberlain, New York, 1926. Cloth, 5 × 8 in., 200 pp., illus., diagrams, 7s. 6d.

Aims to assist students and workmen to an understanding of methods for laying out machine-tool operations so as to insure profitable production. The book deals with both small and heavy work, and is illustrated by examples from English or American practice. Practically all the ordinary machine-shop operations are introduced.

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada)

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ACCELEROMETERS

Riding Qualities, Tests for. Instrumentation and Results of Riding-Qualities Tests, R. W. Brown. Soc. Automotive Engrs.—Jl., vol. 18, no. 6, June 1926, pp. 593–600, 16 figs. Ultimate successful measurement of riding qualities is indicated by design and construction of several new accelerometers; elaborate machine has been constructed which will produce simple harmonic motion to very high degree of accuracy and which provides convenient and highly accurate method of calibrating accelerometers in terms of known fundamentals; measurements of axle accelerations and displacements indicate need of concentration at this time on correlation of various factors entering into riding qualities.

AERODYNAMICS

Model Experiments. Mechanism of Air Currents (Mécanique des fluides et pilotage), Aéronautique, vol. 8, no. 83, Apr. 1926, pp. 126–127, 6 figs. Experiments of Thoret in wind tunnels to demonstrate eddy currents, etc., due to mountains and valleys, and application of results in practical flying.

AERONAUTICS

Physics Applied to Research. The Relationship of Physics to Aeronautical Research, H. E. Wimperis. Engineer, vol. 141, no. 3674, June 11, 1926, pp. 613–614. Theory and design of airfoils, helicopters, scale effect in model testing; seaplane models; airplane-engine developments.

AERONAUTICAL INSTRUMENTS

Aircraft Bubble Sextant. The Aircraft Bubble Sextant, Type A, R. C. Parker. Am. Soc. Nav. Engrs.—Jl., vol. 38, no. 2, May 1926, pp. 301–317, 4 figs. Constructed to fill requirements of instrument with which altitude of heavenly bodies can be measured without depending on sea horizon.

AIR COMPRESSORS

Rotary. Theory of Rotary Compressors and Vacuum Pumps of Multicellular Type (Theorie umlaufender Kompressoren und Vakuumpumpen der Vielzellenbauart), H. Baum. Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 19 and 22, May 8 and 29, 1926, pp. 623–628 and 742–746, 18 figs. Abridged yet comprehensive theory of single-stage rotary compressors and vacuum pumps of so-called multicellular type; values and coefficients based on experience, especially with rotary compressors of Wittig type.

Testing. The Heat-Balance Method of Testing Centrifugal Compressors, M. G. Robinson. Refrig. Eng., vol. 12, no. 10, Apr. 1926, pp. 327–335 and (discussion) 335–337, 11 figs. In this method, principle is used that balance exists between mechanical energy supplied by rotation of shaft and heat-energy increase in air which is being compressed, heat-energy increase in cooling water used, and heat loss from casing, bearings and packings.

AIR CONDITIONING

Atmospheres of Low Temperatures. Work Tests Conducted in Atmospheres of Low Temperatures in Still and Moving Air, W. J. McConnell and C. P. Yaglou. Am. Soc. Heat. & Vent. Engrs.—Jl., vol. 32, no. 5, May 1926, pp. 375–386, 7 figs. Results of experiments definitely indicate to what extent atmospheric conditions influence human efficiency.

AIRCRAFT CONSTRUCTION MATERIALS

Corrugated Metal. Corrugated Metal Sheet in Aircraft Structures. Aviation, vol. 20, no. 24, June 14, 1926, pp. 909–910, 6 figs. Possibilities of employing corrugated duralumin for large aircraft components in addition to parts of compound structures.

Dopes. Durability of Airplane Doping and Varnishing Systems, H. A. Gardner. Paint Mfrs.' Assn. of U. S., Sci. Section—Circular, no. 274, June 1926, pp. 61–70, 4 figs. Study of cellulose acetate and cellulose nitrate tautening and proofing schemes for fabric surfaces.

AIRPLANE ENGINES

Air-Cooled. The Air-Cooled Radial Engine, R. W. A. Brewer. Aviation, vol. 20, no. 23, June 7, 1926, pp. 872–874, 2 figs. Outline of general features of air-cooling and radial type of engine.

Air vs. Water Cooling. Air-Cooled or Water-Cooled Airplane Engines (Moteurs d'avions à refroidissement par air ou par eau), J. A. Lefranc. Nature (Paris), no. 2716, Apr. 24, 1926, pp. 262–269, 6 figs. Technical advantages and disadvantages of air cooling and water cooling; rivalry between two types in France; balance of evidence is in favor of air cooling.

Fairchild-Caminez. Cam is Used Instead of Crank Train in Radial Airplane Engine, A. F. Denham. Automotive Industries, vol. 54, no. 21, May 27, 1926, pp. 891–893, 3 figs. New 4-cylinder, air-cooled engine constructed for commercial use by Fairchild-Caminez Corp.; large cylinders give output of 150 hp.

The Fairchild-Caminez Engine. Aviation, vol. 20, no. 21, May 24, 1926, pp. 788–791, 6 figs. Details of four-cylinder air-cooled radial engine fitted into Avro 504K-type machine; design is result of inventor's effort to produce mechanism which would give four strokes per revolutions to coincide with four-strike cycle employed in internal-combustion engines; special features of engine and results of tests.

Pratt & Whitney Wasp. The Pratt & Whitney Wasp Engine. Aviation, vol. 20, no. 22, May 31, 1926, pp. 827–828, 2 figs. New 400-hp. air-cooled radial engine passes flight tests with excellent results.

AIRPLANE PROPELLERS

Strength Determination. Propeller Design, F. E. Weick. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 238, June 1926, 11 pp., 7 figs. Simple method for determining strength of propellers of standard form and sufficient for safe operation; paper also gives approximate method of stress analysis.

AIRPLANES

Airfoils. Pressure Distribution Over Thick Tapered Airfoils, N. A. C. A. 81, U. S. A. 27 C Modified and U. S. A. 35, E. G. Reid. Nat. Advisory Committee for Aeronautics—Report, no. 229, 1926, 18 pp., 25 figs. Results of tests conducted in 5-foot atmospheric wind tunnel of Langley Memorial Aeronautical Laboratory, object of which was measurement of pressures over three representative thick tapered airfoils which are being used on existing or forthcoming Army airplanes; results are presented in form of pressure maps, cross-span load and normal-force coefficient curves and load contours.

Calculation. Elements of a New Method for Aerodynamic Calculation of Airplanes (Elementi per un nuovo metodo di calcolo aerodinamico degli aeroplani), G. Costanzi. Rendiconti Tecnici della Direzione Generale del Genio Aeronautico, vol. 14, no. 1, Mar. 1926, pp. 1–74, 87 figs. Series of experiments with various types of wings, variation of bearing power with velocity and resistance; new method of calculation based on tests with models.

Commercial. German and English Commercial Airplanes (Deutscher und englischer Verkehrsflugzeugbau), A. Gymnich. Luftfahrt, vol. 30, no. 8, Apr. 20, 1926, pp. 115–116, 5 figs. Compares engine horsepower, passengers carried, horsepower per passenger, velocity, etc., of 8 British and 8 German types of planes.

Consolidated PT-1. Static Test of Consolidated Aircraft Company's PT-1 Airplane, E. R. Weaver. Air Service Information Circular, vol. 6, no. 559, Mar. 15, 1926, 31 pp., 49 figs. Static test to determine structural strength of airplane, which, with exception of aileron horn and shock-absorber bridges on landing chassis, meets all structural requirements for primary training airplane.

Control at Low Speeds. On the Control of Airplanes at Low Speeds, W. L. LePage. Aviation, vol. 20, no. 22, May 31, 1926, pp. 829–831, 3 figs. Generalizing on some of methods of obtaining adequate control in stalled flight, with discussion of Hill tailless airplane.

Developments. Airplanes Greatly Improved With Recent Developments in Aerodynamics, L. H. Allen. Automotive Industries, vol. 54, no. 21, May 27, 1926, pp. 898–899, 2 figs. Advantages of tailless plane, Autogiro, and slotted wing and flap are described by A. Klemin before Soc. Automotive Engrs. Metropolitan Section; further radical improvements predicted.

Drag. Notes on Airplane Performance From the Standpoint of the Modern Conception of Drag, J. A. Roche. Air Service Information Circular, vol. 6, no. 560, Mar. 15, 1926, 7 pp., 5 figs. Simple and practical explanation of modern conception of aerodynamic drag, and how it can be used in estimating power consumption of airplanes.

Farman. The Farman F 140 Bn 4 Super Goliath Airplane (L'avion Farman F 140 Bn 4, Super-Goliath), Aérophile, vol. 34, no. 5–6, Mar. 15, 1926, pp. 69–72, 3 figs. Describes new 12-ton airplane, equipped with four 500-hp. Farman engines; speed, 185 km. per hr.

Flying Boats. See FLYING BOATS.

Gliders. Note on the Minimum Speed From Which the Direction of a Gliding Aeroplane Can Be Changed to a Horizontal Path for Landing, F. W. Meredith. Aeronautical Research Committee—Reports and Memoranda, no. 993, June 1925, 5 pp., 1 fig. It is assumed that airplane must be flying horizontally at moment of contact and this analysis defines motion of approach to ground when wings are given maximum possible lift; for normal airplane speed must be about 20 per cent above stalling speed to provide necessary excess lift for flattening out.

Ireland Meteor. The Ireland Meteor. Aviation, vol. 20, no. 23, June 7, 1926, pp. 878–879, 4 figs. New four-passenger commercial airplane with OX-5 engine.

Landing in Fog. Landing Aircraft in Fog, H. Cooch. Roy. Aeronautical Soc.—Jl., vol. 30, no. 186, June 1926, pp. 365–382 and (discussion) 382–393, 9 figs. Account of work which has been done by Electrical Research Station, Air Ministry, and in Electrical Department at Royal Aircraft Establishment, Farnborough; in problem presented, it was assumed that airplane had been guided to vicinity of airdrome and required means for landing safely from height of about 1000 ft. when ground was obscured by fog or mist.

Maintenance and Depreciation. Maintenance and Depreciation of Airplanes and Engines, E. W. Dichman. Mech. Eng., vol. 48, no. 6, June 1926, pp. 574–577. Careful analysis of cost of maintenance and depreciation of number of typical service airplanes of important Army training field; on basis of his figures, author estimates probable cost per airplane-hour and per passenger-mile of possible air-transportation ser-

Note.—The abbreviations used in indexing are as follows:
Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

vice; stresses economic importance of designing aircraft with due regard to ease of maintenance and inspection.

Military. The Vickers-Wibault Fighter. Aviation, vol. 20, no. 24, June 14, 1926, pp. 911–912, 6 figs. All-metal single-seater pursuit plane of French and British origin, known as type 7C.I.; it is high-wing braced monoplane; duralumin construction; engine is 420-hp. air-cooled radial Jupiter.

Performance Tests. The Representation of Aircraft Performance Tests, Using Non-Dimensional Variables, With Special Reference to the Prediction of the Effects of Change of Loading on Performance, R. S. Capon. Aeronautical Research Committee—Reports and Memoranda, no. 984, Nov. 1925, 7 pp., 2 figs. Shows that dimensional theory may be applied rigorously when engine power is proportional to any power, integral or fractional, of airscrew rate of rotation, and that in this case, maximum rates of climb and corresponding air speeds and airscrew rates of rotation, as well as maximum level speeds may be obtained at one loading from tests at another loading by simple calculation.

Sikorsky. The Sikorsky Transatlantic Plane. Aviation, vol. 20, no. 22, May 31, 1926, pp. 834–835, 4 figs. New three-engine plane under construction, having small lower and large upper wing; ribs are of U-shaped duralumin sections; equipped with three Gnome-Rhone-Jupiter 400-hp. air-cooled engines.

Stalled Flight. Notes on Stalled Flying, C. Howarth. Roy. Aeronautical Soc.—Jl., vol. 30, no. 186, June 1926, pp. 394–402, 5 figs. Experiments carried out on Avro 2402; method of reduction of observations; important points noticed during experiment; measurement of lag in suspended static system.

The Control of Stalled Aeroplanes, B. M. Jones. Roy. Aeronautical Soc.—Jl., vol. 30, no. 186, June 1926, pp. 345–356 and (discussion) 356–364, 5 figs. Report based on results of researches made by (Brit.) Air Research Committee; to cause airplane to be thoroughly controllable when stalled it is necessary (1) to provide ailerons which can exert sufficient moment about axis passing through center of gravity of airplane inclined through sufficient angle downwards and forwards from mean chord of wings; (2) to provide rudder of sufficient power.

Training. The Blackburn "Sprat." Flight, vol. 18, no. 21, May 27, 1926, pp. 305–308, 5 figs. Training machine convertible into landplane or seaplane; engine fitted as standard is Rolls-Royce Falcon of 275 hp.

Wings. Investigations of Compound Action of Ribs and Longerons in Airplane Wings (Einige Anwendungen der bisher durchgeführten Untersuchungen über Rippenverbundwirkung in Flugzeugflügeln), K. Thalau. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 6, Mar. 27, 1926, pp. 121–129, 9 figs. Results of investigations so far completed and their application; treatment is largely mathematical.

The Aerodynamic Characteristics of Seven Frequently Used Wing Sections at Full Reynolds Number, M. M. Munk and E. W. Miller. Nat. Advisory Committee for Aeronautics—Report, no. 233, 1926, 16 pp., 14 figs. Aerodynamic properties of wing sections, U. S. A. 5, 27, 35 A and 35 B, Clark Y, R. A. F. 15, and Göttingen 387, as determined at various Reynolds numbers up to approximately full-scale value in variable-density wind tunnel.

The Calculation of Airplane Wings (Ueber die Berechnung von freitragenden Flugzeugflügeln), C. B. Biezeno, J. J. Koch and C. Koning. Zeit. für angewandte Mathematik u. Mechanik, vol. 6, no. 2, Apr. 1926, pp. 97–105, 4 figs. Results of tests carried out for purpose of evolving method of calculation for wings such as are used on Fokker airplanes, having two transverse beams connected by ribs in close proximity to one another; development of equations for ribs; differential equations for both beams; power transmission of both beams.

Wissler. Two New Wissler Airplanes. Aviation, vol. 20, no. 21, May 24, 1926, pp. 792–794, 4 figs. Details of two airplanes of comparatively low power, WA-6, designed as sport plane, equipped with Anzani 75-hp. air-cooled radial engine; WL-9, 2-seater machine and single-bay biplane.

AIRSHIPS

Giant. Giant Airships (Riesenluftschiffe), W. Scherz. Luftfahrt, vol. 30, no. 7, Apr. 6, 1926, pp. 104–106, 6 figs. Discusses developments of successive types of airships from 1850, including German, British and American construction of large-size types.

Mooring Masts. Italian Mooring Mast for Airships (Pilone d'ormeggio Italiano per dirigibili), Rivista Aeronautica, vol. 2, no. 3, Mar. 1926, pp. 93–101, 7 figs. Design and static calculation of mooring mast at Ciampino, 35 m. high, based on English type by Scott; operation of mooring and releasing.

Semi-Rigid. The Italian Dirigible in Its Latest Examples: the N Type (Il dirigibile italiano nelle sue piu recenti realizzazioni: il tipo N), U. Nobile. Rivista Aeronautica, vol. 2, no. 4, Apr. 1926, pp. 40–53, 6 figs. Characteristics of lighter-than-air types; technique of construction; development of types P, M, and N, latest semi-rigid type of 51,000 cu. m. capacity, which is largest that can be housed in Ciampino hangar.

Stability. Stability of Airships (La stabilita delle aeronavi), G. A. Crocco. Rivista Aeronautica, vol. 11, no. 5, May 1926, pp. 3–32, 15 figs. Discusses experimental work of Renard and Crocco, Pannel and Jones; coefficient of stability and calculation; experiments with types M and G in Italy, etc.

ALLOY STEEL

High-Grade. Progress in the Field of High-Grade Alloys (Neue Fortschritte auf dem Gebiet der Hochleistungslegierungen), E. H. Schulz, W. Jenge and F. Bauerfeld. Zeit. für Metallkunde, vol. 18, no. 5, May 1926, pp. 155–158, 8 figs. Deals with cobalt magnet steel and alloys of stellite class for cutting purposes; applications; resistance to temperature changes and to corrosion.

Resistance and Thermoelectromotive Potential. The Specific Resistance and Thermoelectromotive Potential of Some Steels Differing Only in Carbon Content, E. D. Campbell and H. W. Mohr. Iron & Steel Inst.—Advance Paper, no. 4, for mtg. May 1926, 18 pp., 5 figs. Account of research, object of which was to obtain additional data showing influence of changes in total carbon content on specific resistance and on thermoelectromotive potential of nearly pure iron-carbon alloys and of derivatives from three alloy steels, comprising nickel, chrome-nickel and chrome-vanadium steel. Also abstract in Iron & Coal Trades Rev., vol. 112, no. 3039, May 28, 1926, pp. 845–847.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Iron. See IRON ALLOYS.

ALUMINUM ALLOYS

Aging. Aging of Aluminum Alloys, K. L. Meissner. Metal Industry (Lond.), vol. 28, nos. 16, 17 and 19, Apr. 16, 23 and May 7, 1926, pp. 363–364, 391–393 and 439–440, 7 figs. Its effect upon electrical conductivity and chemical resistance. Discusses obscure phenomena of aging and various theories which have been advanced to account for its occurrence; influence of aging and some of other properties of aluminum alloys, and function of magnesium silicide compound, to which age-hardening effects are sometimes ascribed.

Aluminum Bronze. See ALUMINUM BRONZE.

Castings. Impact Tests Show Fitness of Cast Aluminum Alloys, J. Strauss. Foundry, vol. 54, no. 11, June 1, 1926, pp. 426–429, 4 figs. Summary of impact resistance of alloys in common use at present time; tabular data on mechanical properties of various aluminum alloys.

Duralumin. See DURALUMIN.

Heat Treatment. Heat Treatment of Aluminum-Copper Alloys (Recherches sur le traitement thermique des alliages aluminium-cuivre), L. Guillet and J. Galibourg. Revue de Métallurgie, vol. 23, no. 3, Mar. 1926, pp. 179–190, 22 figs.; also translated abstract in Metallurgist (Supp. to Engineer, vol. 141, no. 3672), May 28, 1926, pp. 78–79. Investigation of behavior under heat treatment of alloys of aluminum with copper; study of hardness of alloys; observations on resistivity; measurements of hardness and of dimensions carried out on two pistons made of one alloy containing 13 per cent copper; heat treatments were performed in baths of water, oil or salt; alloys of 5 to 35 per cent copper are harder as cast than cooled in air; tempering at 100 deg. cent. for an hour immediately after quenching decreases hardness below that of alloys in quenched state.

Strength Improvement. Improvement of Aluminum Alloys (Die Veredelungsvorgänge in vergutbaren Aluminiumlegierungen), K. L. Meissner. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 17, no. 6, Mar. 27, 1926, pp. 112–121, 17 figs. Review of investigations covering improvement of strength by aging; results show that in duralumin, substance which increases strength is magnesium-silicon compound, while in magnesium-free alloys copper-aluminum compound takes its place; greatest hardness and strength, but also less ductility is obtained when aging takes place at somewhat increased temperature, around 150 deg. cent.; aging of these alloys impairs their ability to resist corrosion; author thinks duralumin is better than any alloy developed to replace it; includes diagrams showing behavior of Lautal.

ALUMINUM BRONZE

Acid-Resisting. Acid-Resisting Bronze, W. E. Corse. Iron Age, vol. 117, no. 24, June 17, 1926, pp. 1707, 1 fig. Advantage of alcumite in pickling equipment; properties of new aluminum alloy.

AMMONIA COMPRESSORS

Diagrams. Analyzing Ammonia Compressor Diagrams, W. H. Motz. Power, vol. 63, no. 21, May 25, 1926, pp. 812–813, 1 fig. Method developed by author of laying out adiabatic compression curve which will give correct location of points on compression curve to show relation of pressures and volumes of ammonia under actual working conditions, but compressed adiabatically.

AUTOMOBILE ENGINES

Carbon Deposition. Influence of Temperature, Fuel and Oil on Carbon Deposition, S. P. Marley, C. J. Livingstone and W. A. Gruse. Soc. Automotive Engrs.—Jl., vol. 18, no. 6, June 1926, pp. 607–612, 6 figs. Experimental study of three factors believed to be important in formation of carbonaceous deposits in internal-combustion engines; suggestions are offered for avoidance of carbon trouble.

Fuels. See AUTOMOTIVE FUELS.

Heavy-Oil. The Machonin Process (Das Machonin-Verfahren), S. I. Lavroff. Petroleum, vol. 22, no. 10, Apr. 1, 1926, pp. 378–381, 5 figs. Details of French patent for process of operating internal-combustion engines by means of heavy oils, vegetable oils, etc.; and an internal-combustion engine for purpose, oil being fed to engine in gaseous or liquid state.

Lubricants. See LUBRICATING OILS, Automobile-Engine.

Supercharging. Drive Shafts and Bearings Are Chief Supercharger Design Problems, D. Gregg. Automotive Industries, vol. 54, no. 21, May 27, 1926, pp. 884–888, 10 figs. Parts for centrifugal-compressor type must be proportioned to give adequate factor of safety without being too heavy; anti-friction bearings sometimes wear longer when run dry.

Supercharging Investigated From the Thermodynamic Standpoint, S. R. Treves. Automotive Industries, vol. 54, no. 23, June 10, 1926, pp. 972–981, 5 figs. Analytical study of effects of supercharging on power output and brake thermal efficiency with discussion of general characteristics of supercharged engines for automobiles. See also editorial contribution entitled, Thermal Efficiency Calculated by Dr. Treves Probably Unobtainable with Ordinary Fuels, pp. 981 and 1022.

Valve Guide, Tooling. Tooling for a Valve Guide, F. H. Colvin. Am. Mach., vol. 64, no. 24, June 17, 1926, pp. 935–936, 6 figs. Fixtures and methods for an unusual design of valve guide used in new Stutz engine; automatic turning and grinding machines used.

AUTOMOBILES

Bentley. The Three-Litre Bentley. Auto-Motor Jl., vol. 31, no. 16, Apr. 22, 1926, pp. 333–335, 9 figs. Equipped with 4-cylinder engine incorporating clutch and transmitting power to separate, 3-point suspended gear box which gives 4 forward gear ratios and transmits power via open cardan shaft to spiral bevel-driven rear axle.

Brakes. A Front Braking Problem, W. G. Aston. Autocar, vol. 56, no. 1596, May 21, 1926, pp. 807–808, 3 figs. How front brakes may lose their efficiency through unequal wear between front and rear brake linings.

Fiat. The 7-H.P. Fiat. Auto-Motor Jl., vol. 31, no. 17, Apr. 29, 1926, pp. 353–355, 8 figs. New small model of light weight, long wheelbase and high speed.

Frames, Riveting. Riveting of Automobile Frames Is Production Operation, J. F. Frogett. Iron Trade Rev., vol. 78, no. 23, June 10, 1926, pp. 1489–1491 and 1498, 6 figs. Features of methods in vogue for frame assembly at Star plant, Lansing, Mich., of Durant Motor Co.

Gwynne. The Gwynne Car. Auto-Motor Jl., vol. 31, no. 18, May 6–20, 1926, pp. 374–376, 9 figs. Specially designed for fast and comfortable driving; it has four-seater body; 4-cylinder monobloc engine is separate unit and gear and back axle another unit.

Headlights. Complementary-Color Headlighting, K. D. Chambers. Soc. Automotive Engrs.—Jl., vol. 18, no. 6, June 1926, pp. 613–618, 5 figs. Complementary color system is based upon use of differentiated light, that is, light having different wave lengths; results of tests.

Racing. 91½ Cu. In. Cars Make Good Showing in First Test at Indianapolis, S. Shelton and W. L. Carver. Automotive Industries, vol. 54, no. 22, June 3, 1926, pp. 917–921, 11 figs. Facts about 1926 Indianapolis race; speed during early part of race comparable with that of larger cars preceding year; Miller Special wins with average of 94.63 m.p.h. for 400 miles; features of cars and engines; two types of superchargers; Hamlin front drive.

Rear-Axle Gears. See GEARS, HYPOID REAR-AXLE.

Testing. Testing Products From the User's Angle, G. E. Hagemann. Mfg. Industries, vol. 11, no. 6, June 1926, pp. 431–434, 7 figs. Proving ground established by General Motors Corp. near Milford, Mich., equipped for testing of automobiles in actual service.

Tires. See TIRES, RUBBER.

Transmissions. Turbo-Transmission (Angaben über ein Turbo-Getriebe), G. Bergmann. Motorwagen, vol. 29, no. 8, Mar. 20, 1926, pp. 163–166, 9 figs. Gives experimental efficiency data for turbo-transmission consisting of integral combination of centrifugal pump elements and turbo elements; by displacing pump elements axially, two combinations can be secured, first and second speed; advantages of transmission are silence and very smooth and easy gear shifting.

AUTOMOTIVE FUELS

Alcohol-Ether Mixture. Making Alcohol-Ether Mixture in Cuba for Motor Fuel, E. Humboldt. Chem. and Met. Eng., vol. 33, no. 6, June, 1926, pp. 332–336, 6 figs. How plant was designed and constructed for fermentation of waste molasses in order to take advantage of peculiar economic as well as climatic conditions in tropics.

Anti-Knock. Anti-Knock Motor Fuels Derived from Cracking Shale Oils, J. C. Morrell and G. Egloff. Petroleum Times, vol. 15, no. 383, May 15, 1926, 807–809. Shale oils of American, Australian and French origin have been cracked into yields of gasoline in excess of 50 per cent, based upon charging oil; chemical analysis of cracked gasoline indicates it has high anti-knock properties as motor fuel; methods of treating cracked distillate obtained from cracking of shale oil; oil shale as potential source of motor fuel in United States is sufficient to fulfill requirements for over 150 years, based on present requirements of consumption.

Finding an Anti-Knock Material, T. Midgley, Jr., Tech. Eng. News, vol. 7, no. 3, May 1926, pp. 119, 140 and 142. Explanation of cause of knock in internal-combustion engines and story of discovery of its preventive, tetraethyl lead.

Gasin, a New Anti-Knock Motor Fuel (Gasin, ein neuer Betriebsstoff für Explosionsmotors), G. Grote. Chemiker-Zeitung, vol. 50, no. 47, Apr. 24, 1926, pp. 289–290. Points out that main difficulty with regard to proper inhibition of knocking is ignorance of its true cause; two chemists, Tern and Hloch, claim to have solved problem and arrive at conclusion that degree of knocking is proportional to insulating power of fuel used; they use substances by means of which self-ignition and intermittent increases of pressure leading to detonation are prevented, while at the same time explosive power of fuel is increased.

Dopes and Detonation. Dopes and Detonation, H. L. Callendar, R. O. King and C. J. Sims. Engineering, vol. 121, nos. 3145, 3146, 3147, 3148 and 3149, Apr. 9, 16, 23, 30 and May 21, 1926, pp. 475–476, 509–511, 542–545, 575–576 and 605–608, 15 figs. Account of investigation, as follows: (1) Theoretical aspects, with brief summary of previous experimental work leading up to possible explanation of action of anti-detonating substances; (2) nuclear theory of self-

ignition, summarizing main points of working hypothesis devised to account for peculiar features of detonation with special reference to effect of dopes; (3) experiments in sealed tubes, describing experiments of physical nature on properties of various selected substances; (4) test of same substances in variable-compression engine, to illustrate correspondence of their physical properties with their effectiveness or otherwise in retarding occurrence of detonation. Investigation made at Air Ministry Laboratory, Imperial College of Sci. & Technology.

France. Increased Consumption of Oil Fuels in France and How to Meet It (L'accélération de la consommation de carburants en France, et les moyens d'y faire face), A. Grebel. Génie Civil, vol. 88, no. 17, Apr. 24, 1926, pp. 372–375, 1 fig. Details of production, import and consumption of benzol; use of tar products, gaseous and solid fuels; production of synthetic fuels; reducing consumption by increasing engine efficiency, etc.

Gasoline. See GASOLINE.

Heavy. Experimental Investigation of the Physical Properties of Medium and Heavy Oils, Their Vaporization and Use in Explosion Engines, F. Heinlein. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 363, May 1926, 37 pp., 16 figs. On basis of experiments, author was able to investigate thoroughly described phenomena of obtainable vapor pressures with increased volume and constant temperature. Translated from Motorwagen, Oct. 31, Dec. 20, 1925 and Feb. 10, 1926.

Motalin. German Firm Describes Iron Carbonyl as Effective Anti-Knock Fluid, P. Truesdell. Nat. Petroleum News, vol. 18, no. 22, June 2, 1926, pp. 71–74, 4 figs. Details of new fuel, Motalin, produced by Badische Anilin & Soda Fabrik; experimental evidence confirm its usefulness. See also description in Automotive Industries, vol. 54, no. 21, May 27, 1926, pp. 894–895, 4 figs.

Motalin (Motalin), Ostwald. Allgeneine Automobil-Zeitung, vol. 27, no. 17, Apr. 24, pp. 21–25, 8 figs. Disadvantages of benzine (gasoline), impurities, knocking, etc.; properties of motalin, produced by Badische Anilin- u. Soda-Fabrik, consisting of dapolin with an addition of 0.4 per cent of motyl, an anti-knock compound.

Motalin (Motalin), Allgemeine Automobil-Zeitung, vol. 27, no. 15, Apr. 15, 1926, p. 15. Shows that criticism as to its properties are unfounded.

Service Problems. Fuel From the Service Standpoint, T. A. Boyd. Soc. Automotive Engrs.—Jl., vol. 18, no. 6, June 1926, pp. 641–646, and (discussion) 646–648, 16 figs. Among service problems arising from use of gasoline are presence, in some cracked distillates that have not been properly refined, of brown varnish-like resin, formation of which increases with age of liquid and warmth of place of storage; another source of trouble is due to fact that resinous material tends to collect dirt; remedies proposed.

AVIATION

Coast Defense. The Influence of Aviation Upon Coast Defense, W. T. Carpenter. Coast Artillery Jl., vol. 64, no. 5, May 1926, pp. 464–475. It is concluded that net effect of aviation upon coast defense has been to advantage of defense, since aviation has increased power of shore armament over that of naval armament; that fixed primary armament, anti-aircraft artillery and submarine mines are most dependable means for defense of important harbors against naval attack; that observations aircraft and baloons should be permanently assigned to defenses of most important harbors.

Future of. The Future of Air Transport. Engineering, vol. 121, no. 3149, May 21, 1926, pp. 598–599. Review of lecture by W. S. Brancker, presenting survey of British position; figures are given illustrating present position. See also Engineer, vol. 141, no. 3671, May 21, 1926, p. 518.

B

BEARINGS

Anti-Friction. Anti-Friction Bearings on Steel Mill Motors, A. G. Place. Indus. Engr., vol. 84, no. 6, June 1926, pp. 260–262, 5 figs. Operating results obtained by use of anti-friction bearings and factors considered in applying them to all bearings on 32 traveling cranes.

Overhead-Camshaft. Fixtures for Overhead-Camshaft Bearings, F. H. Colvin. Am. Mach., vol. 64, no. 23, June 10, 1926, pp. 905–906, 6 figs. Bronze self-contained bearing, that requires careful work and is made in special fixtures; bearing surface is ground automatically.

BEARINGS, BALL

Railway Cars. Ball and Roller Bearings for Rolling Stock (Kugel- oder Rollenlager für Schienen-Fahrzeuge), Scherz. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 19, May 8, 1926, pp. 629–634, 10 figs. Investigation of advantages and disadvantages of ball and roller bearings, with particular reference to freight cars.

BELT DRIVE

Calculation. Safety Factor in Belt Transmission (Le coefficient de sécurité dans la transmission par courroie), G. Balachowsky. Electricité & Mécanique, no. 10, Jan.-Feb. 1926, pp. 1–8, 24 figs. Discusses present method of calculating belting and shows that it may lead to erroneous results so far as safety factor is concerned.

Crossed-Belt. Operating Characteristics of Crossed-Belt Drives, R. F. Jones. Indus. Engr., vol. 84, no. 6, June 1926, pp. 267–271, 6 figs. As determined by series of tests, with particular reference to minimum center distances which can be used in laying out such drives.

BOILER FEEDWATER

Locomotive Boilers. Experiments in Preheating Locomotive Feedwater (Esperimenti con preriscaldatori d'acqua per locomotive), G. Corbellini. Rivista Tecnica Ferrovie Italiane, vol. 29, no. 4, Apr. 15, 1926, pp. 140–150, 5 figs. Experiments carried out by Italian State Railways with apparatus for preheating feedwater with exhaust steam; heat balance and how affected by locomotive operation; economics and efficiency; limitations of preheaters.

BOILER FURNACES

Air Preheaters. Comparative Performance of Air Preheaters, N. E. Funk. Mech. Eng., vol. 48, no. 6, June 1926, pp. 562–566, 11 figs. Results of tests on number of boiler units equipped with air preheaters and one unit using unheated air; curves presented show comparative performances of units, relation between coal fed and flue-gas temperature, relation between gas-temperature drop and air-temperature rise and percentage of rating, and relation between percentage of combustible in ash and coal fed.

Increasing Boiler Efficiency by Air Preheaters and Economizers (Die Erhöhung des Dampfkesselwirkungsgrades durch Luftvorwärmer und Ekonomiser), W. Christ. Wärme, vol. 49, nos. 16 and 17, Apr. 16 and 23, 1926, pp. 273–277 and 296–298, 6 figs. Discusses bases upon which relative efficiencies and costs of economizers, air heaters and combined equipments may be determined; by means of numerical examples, author demonstrates requirements, possibilities and limitations of economizers and air heaters used separately, and economizers and air heaters used either in series or in parallel; applications of air heaters are becoming extended, whereas those of economizers are becoming restricted. See brief translated abstract in Power Engr., vol. 21, no. 243, June 1926, p. 232.

Combined Oil- and Gas-Burning. Combined Oil- and Gas-Burning Furnaces for Power-Plant Use, J. G. Rollow. Mech. Eng. (Supp.), vol. 48, no. 6, June 1926, pp. 683–685, 7 figs. Deals with combinations of equipment for best meeting required conditions.

Combustion in. Combustion of Volatiles in Furnaces with Traveling Grate (De la combustion des matières volatiles dans les foyers à grille mécanique), V. Kammerer. Société Industrielle de Mulhouse—Bul., vol. 92, no. 2, Feb. 1926, pp. 111–133, 7 figs. Results of tests carried out in various types of furnaces; concludes that by means of secondary air greater part of unburned gases from coal with high volatile content will disappear, reducing smoke, etc.

Feedwater vs. Air Preheating. Feedwater vs. Air Preheating in Boiler Furnaces (Speisewasser- oder Luftvorwärmung hinter Dampfkesseln?), W. Tafel. Stahl u. Eisen, vol. 46, no. 19, May 13, 1926, pp. 635–640. Points out that question as to whether it is better to preheat air or feedwater with waste heat of a boiler cannot be decisively answered; general effect is about the same for both processes; with feedwater preheating, increase in efficiency is greater and operating difficulties are less; in certain cases, examples of which are given, preheating of combustion air in place of feedwater has been found advantageous.

Lignite—Pulverized-Coal Burning. Step Grates for Firing Crude Lignite with Pulverized-Coal Addition (Treppenrost für Rohbraunkohle mit Kohlenstaubzusatzfeuerung), Wegener. Elektrizitätswirtschaft, vol. 25, no. 405, Mar. 2, 1926, pp. 129–132, 2 figs. Details of coal-preparing and pulverized-coal auxiliary plants at Gustav works in Dettingen (Germany); results of operating practice, and advantages of pulverized addition.

Oil-Burning. Practical Handling of Fuel Oil Burning Equipment, A. F. Brewer. Combustion, vol. 14, no. 5, May 1926, pp. 308–312, 5 figs. Deals with furnaces for burning oil fuel; details of construction; checkerwork design; oil-burner location; lining and setting requirements; furnace volume.

Pulverized-Coal. Evolution of Combustion Volumes in Design of Boiler Furnaces for Pulverized Fuel, H. W. Brooks. Engrs.' Soc. West. Pa.—Proc., vol. 42, no. 1, Feb. 1926, pp. 18–45 and (discussion) 46–59, 11 figs. Combustion volumes for stoker furnaces; furnace combustion volumes with pulverized fuel; fundamentals of pulverized-fuel combustion; past and present methods of pulverized-fuel firing.

New Type of Watercooled Furnace for Pulverized Fuel, C. Voetsch. Power, vol. 63, no. 23, June 8, 1926, p. 892, 1 fig. Some time ago former Vickers-Spearing Boiler Co., London, Eng., developed pulverized-coal furnace which was purchased by Stinnes concern to be installed near Hamburg, but never delivered; cooling of furnace walls was accomplished by means of air ducts in furnace walls, preheated air then being turned into combustion chamber or by means of feedwater leads built into wall or in front of it, thus protecting inner wall surface against intense heat.

BOILER PLANTS

Automatic Regulation. Automatic Regulation of a Small Boiler Plant, E. Therkelsen. Power, vol. 63, no. 22, June 1, 1926, pp. 846–847, 3 figs. How one plant solved problem of automatic regulation and achieved increased average economy from $5^1/_2$ to $6^1/_2$ lb. equivalent evaporation per pound of coal fired, and gave fireman time to keep plant clean and in perfect repair and make him ready for any emergency.

BOILER PLATE

Embrittlement. The Cause and Prevention of Embrittlement of Boiler Plate, S. W. Parr and F. G. Straub. Am. Soc. Testing Matls.—Preprint, no. 26, for mtg. June 21, 1926, 28 pp., 13 figs. Three types of cracks are recognized; those due to direct corrosion of metal, those due to fatigue, and those caused by caustic solutions; includes photomicrographs of both natural and artificially produced cracks which furnish method of identification and illustrate their special characteristics.

BOILER TUBES

Corrosion. The Influence of Segregation on the Corrosion of Boiler Tubes and Superheaters, G. R. Woodvine and A. L. Roberts. Iron & Steel Inst.—Advance Paper, no. 16, for mtg. May 1926, 4 pp., 6 figs. Results of experiments made in order to determine extent to which pitting and general corrosion in tubes could be ascribed to segregated ingot material. See abstract in Engineering, vol. 121, no. 3150, May 28, 1926, pp. 646–647, 3 figs.; also Iron & Coal Trades Rev., vol. 112, no. 3039, May 28, 1926, pp. 841–842.

BOILERS

Flue-Sheet Combustion Chamber. Flue Sheet Combustion Chamber and Other Types of Boilers. Ry. Jl., vol. 32, no. 6, June 1926, pp. 36–37. Committee report before Master Boiler Makers Assn.

Heads. Investigation of Stresses and Deformation in Dished Boiler Heads With or Without Manhole (Versuche über die Anstrengung und die Formänderungen gewölbter Kesselböden mit und ohne Mannloch bei der Beanspruchung durch inneren Druck), E. Siebel and F. Körber. Kaiser-Wilhelm-Institut für Eisenforschung zu Düsseldorf—Mitteilungen, vol. 10, no. 7, 1926, pp. 113–130, 23 figs. First report shows that lowest stresses occur in elliptic heads or those of basket-handle shape approaching elliptic; highest stresses occur at manholes, also maximum deformation.

Most Favorable Shape of Oval Boiler Heads (Ueber die günstigste Form der Meridianlinie korbbogenförmig gewölbter voller Kesselböden), A. Justus. Zeit. Bayerischen Revisions-Vereins, vol. 30, no. 6, Mar. 31, 1926, pp. 63–65, 3 figs. Further explanation and calculation of Otte's oval heads or basket curve; (see no. 22, 1925); develops formulas for calculating these heads for any boiler, endeavoring to combine greatest flange radius with smallest radius of curvature.

High-Pressure. High Pressure Steam and Its Increased Importance in Generation of Electric Power (Der Hochdruckdampf und seine erhöte Bedeutung für die Erzeugung elektrischer Energie), Wintermeyer. Elektro-Jl., vol. 6, no. 3–4, Feb. 25, 1926, pp. 57–62, 5 figs. Discusses development of high-pressure boiler operation, boiler construction; protective walls consisting of cooled pipes; feedwater heating; pulverized-coal firing; increased economy from high-pressure operation; Benson, Schmidt and Loeffler types of boilers.

Locomotive. See LOCOMOTIVE BOILERS.

Natural-Gas-Fired. Large Natural-Gas Fired Boilers, W. S. Johnston. South. Power Jl., vol. 44, no. 5, May 1926, pp. 40–42, 2 figs. Details of boilers installed in power station on Ouachita River near Sterlington, La., of three-pass cross-drum type set to be fired under low end headers and carried on their own steel supports; burners under each boiler are seven in number, each consisting of gas chamber or box into which 105 pipes are connected, each pipe terminating in burner tip.

Stoker-Fired. Another Stoker-Fired Boiler Shows High Efficiency, D. J. Mosshart. Power, vol. 63, no. 24, June 15, 1926, p. 325, 1 fig. Efficiency ranging from 78 to 84 per cent for boiler without economizer or air preheater is shown by series of tests recently conducted by High Bridge Station at St. Paul, Minn.

Waste-Heat. Gas-Fired and Waste-Heat Boilers Colliery Eng., vol. 3, nos. 25 and 26, Mar. and Apr. 1926, pp. 122–124, and 166–167 and 182, 12 figs. Leading features of various types.

BOILERS, WATER-TUBE

Single- and Multi-Pass. Design and Construction Details of Single and Multi-Pass Boilers, A. A. Fette. Nat. Engr., vol. 30, nos. 5 and 6, May and June 1926, pp. 201–204 and 245–249, 19 figs. Consideration of all passes produced by baffle walls and water-tube boilers; particulars of Edge Moor and Bigelow-Hornsby boilers, which are prominent examples of this type. (Abstract.) Paper presented before Nat. Assn. Stationary Engrs.

BRAKES

Air. Investigation Made of Brake Pipe Leakage. Ry. Rev., vol. 78, no. 23, June 5, 1926, pp. 999–1003, 3 figs. Report of committee of Air Brake Assn. contains exhaustive study of entire subject; standing tests with brake-system leakage-testing device.

Lining. Coefficient of Friction of Brake Linings (Coefficient de frottement des garnitures de frein), M. Abadie. Industrie des Voies Ferrées et des Transports Automobiles, vol. 20, no. 230, Feb. 1926, pp. 81–86, 4 figs. Results of tests to determine coefficient of friction and resistance to wear of various materials used as brake linings for buses and street cars.

Magnetic. Magnetic Brakes as Developed by West Penn Railway Company, D. Durie. Aera, vol. 15, no. 4, May 1926, pp. 623–625, 3 figs. Twenty-three years' experience with this type of brake on cars operating on steep grades satisfies management that it is reliable under severe conditions.

BROACHING MACHINES

German Type. Broaching Machine (Räummaschine), Glasers Annalen, vol. 98, no. 9, May 1, 1926, pp. 145–148, 4 figs. Machine tool for producing square, polygon, oval, and other irregularly shaped holes accurately and cheaply by boring maximum diameter hole and finishing required profile by means of cutter.

C

CABLEWAYS

Coal Mines. Aerial Ropeway at Marine Colliery. Iron & Coal Trades Rev., vol. 112, no. 3038, May 21, 1926, pp. 771–773, 8 figs. Cableway is of bi-cable

type, has capacity of 130 tons per hour when rope is running at speed of 110 yd. per min.; it is arranged to discharge both on outgoing and return sides.

Passenger. Funicular Lines for Passenger Transport from the Standpoint of Safety (Le funicolari aeree per trasporto di persone dal lato della sicurezza), I. Bertolini. Ingegneria, vol. 5, no. 3, Mar. 1926, pp. 102–109, 23 figs. Discusses bearing and traction cables, their construction and properties; telpherage systems by Bleichert, Ceretti and Cortirra; funicular line of Mont Blanc between Chamonix and Aignille de Midi for cars with 18 passengers.

CAR WHEELS

Chilled. Chilled Wheel Design Improved, F. K. Vial. Ry. Rev., vol. 78, no. 23, June 5, 1926, pp. 1007–1008, 5 figs. Reinforcing rings and lip-type chillers add to service life of wheels.

CARBON DIOXIDE

Thermal Constants. Some Thermal Constants of Solid and Liquid Carbon Dioxide, O. Maass and W. H. Barnes. Roy. Soc.—Proc., vol. 3, no. A757, May 1, 1926, pp. 224–244, 5 figs. Measurements deal with direct determination of latent heat of fusion, latent heat of sublimation and specific heats of solid and liquid over temperature range of 0 deg. to 184 deg. cent.

CARBON MONOXIDE

Recorders. Development and Characteristics of a Carbon Monoxide Recorder, S. H. Katz, D. A. Reynolds, H. W. Frevert and J. J. Bloomfield. Am. Soc. Heat. & Vent. Engrs.—Jl., vol. 32, no. 5, May 1926, pp. 349–374, 16 figs. Previous development of principle of indicating presence of combustible gases in air by differential temperature effect induced by gases when in contact with catalyst to promote oxidation; principle of CO recorder, mechanism and structure; laboratory tests of recorder and characteristics; performance of CO recorders during extended use.

CARS

Center of Gravity. The Determination of Height of the Center of Gravity of Cars and Locomotives, G. L. Fowler. Ry. & Locomotive Eng., vol. 39, no. 5, May 1926, pp. 134–135, 3 figs. Explains simple method used which is more rapid and accurate than any calculation based upon weights and relative locations of several parts entering into structure can possibly be; principle of method is that of tilting vehicle on one side and determining relation between weight thus imposed on lower wheels and vehicle as a whole.

CARS, FREIGHT

Loading. Car Loading. Pac. Ry. Club—Proc., vol. 10, no. 1, Apr. 1926, 20 pp. between pp. 11 and 36. Includes three papers by A. M. Reinhardt, F. E. Yoakum and R. S. Busby, and discussion; deals with heavier loading of freight cars from tariff standpoint; getting shippers to load heavier.

CARS, PASSENGER

London, Midland & Scottish Railway. New Steel Coaching Stock, London Midland & Scottish Railway. Ry. Gaz., vol. 44, no. 17, Apr. 23, 1926, pp. 582–588, 8 figs. Superstructure of each car is mounted upon standard trucks and is designed in form of long tubular girder, underframe forming bottom boom, and cant rails, purlins and roof sheets the top boom.

CARS, REFRIGERATOR

Packing-House Service. New Refrigerator Car Design is Successful, W. Alexander. Ry. Rev. vol. 78, no. 23, June 5, 1926, pp. 993–996 and 1049–1050, 6 figs. Cars equipped with divided wire basket bunkers which provide larger cooling surface or greater exposed ice surface than employed in conventional wire basket bunker, and at same time reduces ice capacity approximately 25 per cent.

CASE-HARDENING

Gear Stock. Reducing the Cost of Carburizing Transmission Gear Stock, J. B. Nealy. Iron Trade Rev., vol. 78, no. 22, June 3, 1926, pp. 1431–1432, 4 figs. Standardization of all factors involved in carburizing process is necessary for scientific duplication of results desired; describes heat-treating department of well known automobile plant, where two large oil-fired carbonizing furnaces are installed.

Nitridation. Nitridation of Ordinary and Special Steels (Sur la nitruration des aciers ordinaires et spéciaux), L. Guillet. Académie des Sciences—Comptes Rendus, vol. 182, no. 15, Apr. 12, 1926, pp. 903–907. New method of case-hardening steel, which is being applied technically, consists in heating material at 500 to 510 deg. for 6 hours in current of ammonia; investigations show that increase in surface hardness occurs with alloys containing chromium, silicon, molybdenum, and aluminum; increase in hardness is particularly marked in case of steel with high content of aluminum; surface-hardening effect is attributed to influence of added elements in decreasing diffusion of nitrogen by formation of nitrides.

CAST IRON

Analysis. The Rapid Determination of Structural or Constitutional Analysis of Cast Iron. Brit. Cast Iron Research Assn.—Bul., no. 12, Apr. 1926, pp. 14–15. In any consideration of relationship between constitution and mechanical or other properties of gray iron it would be found worth while to consider properties as related to structural analysis, either by weight or volume, instead of to chemical analysis in skeleton form.

High-Strength. The Production of Cast Iron of High Strength (Die Erzeugung von Gusseisen hoher Festigkeit), C. Gilles. Giesserei-Zeitung, vol. 23, no. 8, Apr. 15, 1926, pp. 203–208 and (discussion) 208–212, 12 figs.; also Zeit. für angewandte Chemie, vol. 39, no. 14, Apr. 8, 1926, pp. 458–459. Points out that best results are being obtained in oil-fired cupola furnaces, necessary silicon and manganese being added to melt from outside; Thyssen-Emmel cast iron; Wüst oil-fired furnace; new recommendations; experiments show that cast iron of maximum strength can be produced in cupola without subsequent treatment.

Mechanical Properties and Analysis. The Relation Between the Mechanical Properties and the Analysis of Cast Iron. Brit. Cast Iron Research Assn.—Bul., no. 12, Apr. 1926, pp. 16–20, 5 figs. Presents curves published by Klingenstein which are result of 2000 routine tests made at Esslingen Iron Foundries in Germany on 1.2-in. diameter test bars. Translated from Giesserei, Feb. 27, 1926.

Mechanite. New Cast Iron. Iron Age, vol. 117, no. 21, May 27, 1926, 1559–1560, 2 figs. Mechanite, made by adding calcium silicide to iron and brought out by Ross-Meehan Foundries, Chattanooga, Tenn., has average ultimate tensile strength of 50,000 lb. per sq. in., as compared with 20,000 to 25,000 lb. per sq. in. for ordinary gray iron; material preserves its integrity almost up to its high breaking point.

Refining. Refining Cast Iron (Die Veredelung von Gusseisen), H. Kalpers. Dinglers Polytechnisches Jl., vol. 5, no. 34, Mar. 1926, pp. 45–49. Discusses refining in smelting, production of semi-steel; refining by alloying; concludes that electric furnace and Lanz pearlitic castings represent greatest progress.

Structure. The Structure of Cast Iron. Metallurgist (Supp. to Engineer, vol. 141, no. 3672), May 28, 1926, p. 74. Review of lecture by Hanemann before Betriebsverein Deutscher Ingenieure, in which suggestion is made that when gray iron is melted, whole of graphite present does not at once pass into solution, but that minute flakes of graphite remain suspended in liquid, which dissolve only at higher temperatures; photomicrographs show structure of same iron solidified before and after superheating to 1500 deg. cent.

CENTRAL STATIONS

Belgium. The Langerbrugge Power Station. Engineer, vol. 141, no. 3673, June 4, 1926, pp. 570–573, 17 figs. partly on supp. plate and p. 582. Station near Ghent, Belgium, contains three boilers, capable of normal aggregate output of 79,200 lb. of steam per hr., working at gage pressure of 56 kilos per sq. cm., and at temperature of 842 deg. fahr.; details of equipment; turbo-generator was constructed by Brown, Boveri & Co.

Gennevilliers, France. Record-Breaking Steam Temperatures at Gennevilliers, R. H. Andrews. Power, vol. 63, no. 24, June 15, 1926, pp. 921. Generating unit No. 6 of Gennevilliers central station of city of Paris probably set world's record in commercial service under high-steam temperatures; summary of this service over period of $2^1/_2$ months.

High-Pressure Units. The 1200-Lb. Unit at Edgar Station After Six Months' Operation. Power, vol. 63, no. 24, June 15, 1926, pp. 935–936, 2 figs. Results of experiment of Edison Electric Illuminating Co. of Boston, in putting into commercial operation boiler and turbine unit at more than double pressure used in any existing station and four times pressures ordinarily employed.

Interconnected Steam and Hydro. Some Interconnected-System Operating Problems, F. G. Boyce. Am. Inst. Elec. Engrs.—Jl., vol. 45, no. 5, May 1926, pp. 462–466, 3 figs. Outlines advantages and disadvantages of interconnected system consisting of steam and hydroelectric stations; investment costs are materially reduced because of less reserve capacity being required to insure continuous service; more efficient operation of generating units is possible and operating costs are reduced.

Pulverized-Coal-Burning. Motors and Control for Pulverized Fuel Plants, M. B. Wyman. Elec. Jl., vol. 23, no. 5, May 1926, pp. 236–243, 6 figs. Operating conditions and service requirements; special features of motors and control in pulverized-fuel plant; special applications of motors for drives of equipment.

Small. Outlook Promising for the Small Power Plant, E. Douglas. Power, vol. 63, no. 25, June 22, 1926, pp. 960–961. Trend of central-station business for last five years.

Steam Power and Hydro Supply. Aspects of Steam Power in Relation to a Hydro Supply, A. H. Markwart. Mech. Eng., vol. 48, no. 6, June 1926, pp. 557–561, 9 figs. In final analysis relative development by utility of hydro and steam-generating capacity is problem of economy; natural resources available, character of load to be carried, rate at which energy must be supplied or load factor, extent to which utilities may depend upon it for stand-by and other related elements furnish criteria for its solution; general tendency seems to be for steam-plant ratio to increase slightly; gives data on central-station construction program for 11 western states for 3-year period 1924 to 1926.

CHAIN DRIVE

Automatic Idler. Holding Chain Drives at Constant Tension, F. W. Curtis. Am. Mach., vol. 64, no. 21, May 27, 1926, pp. 823–824, 4 figs. Feature of automatic adjustment is that it not only takes care of any elongation that develops in chain in service, but also insures longer chain life and sustained quiet operation; chain drives with automatic idler can be applied to all styles of metalworking machines in which driving power is between $^1/_2$ and 25 hp.

CHAINS

Strength. Strength of Chains (Zur Festigkeit von Ketten), L. Feimer. Dinglers Polytechnisches Jl., vol. 107, no. 8, Apr. 1926, pp. 81–85, 5 figs. Tests carried out at Budapest Technical High School with circular and oval links showing that Bach formula gives too high values and may lead to serious errors.

CHIMNEYS

Increasing CO_2 in. The Overworked Chimney, C. C. Phelps. Power, vol. 63, no. 21, May 25, 1926, p. 813, 5 figs. Points out that increasing CO_2 materially increases chimney's capacity.

CHUCKS

Self-Centering. A New Self-Centering Chuck. Machy. (Lond.), vol. 28, no. 705, Apr. 1, 1926, pp. 21–22, 4 figs. Refers to self-centering chuck in which chuck jaws are moved by inclined straight teeth instead of by scroll or cam plate, three sets of inclined teeth corresponding with three jaws being moved simultaneously by gear ring meshing with short rack on sliding blocks on which inclined teeth are cut.

COAL

Blending. Coal Blending, D. Brownlie. Iron & Steel Inst.—Advance Paper, no. 2, for mtg. May 1926, 42 pp., 12 figs. Survey of subject of coal blending in connection with carbonization, that is, primarily mixing of swelling bituminous coals with other products such as non-swelling bituminous coals, anthracites and anthracite coals, high-temperature carbonization coke, which may be either metallurgical or household gas coke, low-temperature carbonization fuels, oxidized coals and various constituents of coal. Also abstract in Iron & Coal Trades Rev., vol. 112, no. 3039, May 28, 1926, pp. 837–838.

Pulverized. See PULVERIZED COAL.

CONDENSERS, STEAM

Surface. Auxiliary Supercooling in Surface Condensers, A. J. Nicholas. Power, vol. 63, no. 21, May 25, 1926, pp. 804–805, 4 figs. Condensate vs. steam-air temperatures; effect of supercooling on volumetric efficiency of vacuum pump; it is clear that cooling of residual steam-air mixture leaving condenser, before it reaches vacuum pump, is powerful means of either increasing capacity of pump of existing installation or reducing size of pump required for new job.

Present Problem of Surface Condensers (Le problème actuel du condenseur à surface), A. Delas. Revue Industrielle, vol. 56, no. 2201, Apr. 1926, pp. 153–159, 6 figs. Discusses conditions of effective operation, cleanliness of surfaces on both sides; uniform hourly rate of condensation per unit of surface and uniform speed of steam; gives examples with calculations.

Tubes. Examination of Highly Corroded Brass Condenser Tubes (Untersuchungen von Messingkondensatorrohren mit starker Korrosion), M. v. Schwarz. Elektrizitätswirtschaft, vol. 25, no. 401, Jan. 2, 1926, pp. 36–43, 17 figs. Discusses rapid dezinking of some tubes; composition of incrustation, brass and cooling water; microscopic examination of structure; internal stresses; X-ray examination; effect of tinning and arsenic content.

CONNECTING RODS

Calculation. Testing the Strength of a Connecting Rod (Festigkeits-Untersuchungen an einer Kuppelstange), E. Herms. Praktische Maschinen-Konstrukteur, vol. 59, no. 13–14, Apr. 3, 1926, pp. 126–129, 12 figs. Calculation of connecting rods for electric B+B locomotive of 66 tons weight; maximum buckling load; action of centrifugal force; weight of connecting rod and parts.

Manufacture. A Hundred Connecting Rods Each Month, F. W. Curtis. Am. Mach., vol. 64, no. 22, June 3, 1926, pp. 851–854, 9 figs. Methods and equipment employed in Sedalia shops of Missouri Pacific Railroad Co.

Connecting Rods in the Stutz Shop, F. H. Colvin. Am. Mach., vol. 64, no. 20, May 20, 1926, pp. 781–783, 8 figs. Main features in locating and machining forged duralumin connecting rods; method of locating; fixture for elongating holes; cutting off caps; testing alignment.

CONVEYORS

Tramrail System. Special Carrying Rail, A. F. Anjeskey. Iron Age, vol. 117, no. 23, June 10, 1926, p. 1651, 1 fig. New development in overhead conveying systems reduces wear and increases life; it eliminates entirely troubles encountered with I-beam.

COOLING TOWERS

Hamon. Recent Improvements in Cooling Towers (Les perfectionnements récents dans les réfrigérants à cheminée), A. Pouillard. Genie Civil, vol. 88, no. 19, May 8, 1926, pp. 417–420, 7 figs. Conditions an effective cooler must fulfill; details of Hamon cooling tower provided with lateral and central ventilation and cellular chambers for dripping of water.

CRANES

Construction and Maintenance. Aspects in Construction and Maintenance of Crane Installations (Gesichtspunkte für Bau und Instandhaltung von Krananlagen), F. Töpfl. Stahl u. Eisen, vol. 46, no. 18, May 6, 1926, pp. 601–609, 20 figs. Guiding rules for construction of buildings and crane runways; tracks, loop lines, bridges, crane frames and girders, driving gear, brakes, driver's cage, electrical equipment, safety devices, etc.; crane inspection and accidents.

Jib, Traveling. A New Type of "Toplis" Level-Luffing Crane. Engineer, vol. 141, no. 3673, June 4, 1926, p. 589, 3 figs. Constructed by Bedford Engineering Co. and installed in Hollicks Wharf of Assoc. Portland Cement Mfrs., where it is employed chiefly to handle cement in bags from barges to storage.

New Toplis Crane (Nouvelle grue toplis), Génie Civil, vol. 88, no. 18, May 1, 1926, pp. 389–391, 8 figs. New type crane for horizontal conveying, constructed by Bergerat & Co. (Bedford Engineering Co.) for unloading sacks of cement; maximum range 14.60 m., speed 36 m. per min.; driven by direct current of 400 volts.

CRANKSHAFTS

Torsional Vibration. Torsional Vibration of Crankshafts, P. M. Heldt. Automotive Industries,

vol. 54, no. 23, June 10, 1926, pp. 957–965, 10 figs. Points out that lower harmonics of gas-pressure curve and not inertia force are principal factor.

CUPOLAS

Practice and Metallurgy. Cupola Practice and Metallurgy. West. Machy. World, vol. 17, no. 5, May 1926, pp. 211–212, 1 fig. Height of coke bed, volume of air and weight of charges of metal and fuel in cupola operations are items that require manipulation, based upon fixed principles; how to figure melting capacity of any size cupolas.

Shaft Furnaces. Melting Practice in the Iron Foundry, with Special Reference to the Shaft Furnace, J. Mehrtens. Foundry Trade Jl., vol. 33, no. 511, June 3, 1926, p. 399. Effect of melting in shaft furnace on quality of cast iron; author claims old cupola or shaft furnace still maintains its position as being simplest and cheapest melting device in iron foundry; recent improvements in shaft furnace.

CUTTING METALS

Oxy-Illuminating Gas. Metal Cutting with Oxy-Illuminating Gas, F. P. Wilson, Jr. Gen. Elec. Rev., vol. 29, no. 6, June 1926, pp. 443–445, 6 figs. Action of metal-cutting torch; design of new torch; comparison of illuminating gas and other gases; superheating; advantages of new torch.

D

DIESEL ENGINES

Applications. Applications, Economics, and Operation of Modern Diesel Engines, G. A. Adkins and R. H. Bacon. Nat. Engr., vol. 30, no. 5, May 1926, pp. 189–195, 6 figs. Applications of modern types of various classes of service; factors to be considered in selection of units; fuel consumption, lubrication and operating requirements; operating costs, first costs, fixed charges and total cost of service under various operating conditions. Paper presented during Oil & Gas Power Week.

Compressorless. Compressorless Engines or Compressorless Diesel Engines (Kompressorlose Maschninen oder kompressorlose Dieselmaschinen), P. Kühnle. Wirtschaftsmotor, vol. 7, no. 10–11, Nov. 25, 1925, pp. 1–5, 4 figs. Concludes that all engines with compression up to 20 atmos. are explosion engines, and those with compression of 33 atmos. and fuel injection after piston passes upper dead point, are Diesel engines.

Double-Acting. The North-Eastern Double-Acting Marine Diesel Engine. Engineering, vol. 121, no. 3150, May 28, 1926, pp. 634–635, 3 figs. on supp. plates. Diesel engine working on 4-stroke cycle, capable of developing 5800 i.hp. in its 6 cylinders, built for installation in motorship Stentor. See also description in Engineer, vol. 141, no. 3672, May 28, 1926, p. 559, 3 figs. on pp. 554 and 558.

High-Speed. Diesel Operates at 900 R.P.M. Power, vol. 63, no. 26, June 29, 1926, pp. 1010–1011, 3 figs. Outlines development of high-speed oil engine for standby service with maximum rating of 40 hp. per cylinder at 900 r.p.m.; solid injection employed; mechanism completely enclosed.

Integral Box Frame. New Fulton Enbloc Frame Diesel Engine. Oil Engine Power, vol. 4, no. 6, June 1926, pp. 356–358, 4 figs. Integral box frame comprising cylinder mountings and crankcase adds rigidity and reduces weight.

Pipe-Line Pump Drive. Oil Engines as a Drive for Pipe-Line Pumps, F. Thilenius. Mech. Eng. (Supp.), vol. 48, no. 6, June 1926, pp. 663–670, 11 figs. Survey of use of Diesel engines for this purpose, covering facts pertaining to pipe-line systems leading out of Mid-Continent area, together with discussion of pipe-line practice and of forms of power previously employed.

DISKS

Rotating. The Rims of Rotating Discs. Engineering, vol. 121, no. 3151, June 4, 1926, p. 649, 3 figs. Points out that width of rim which can be effectively supported by central web is point of importance in design of rotating disks; problem involved was virtually solved by J. Y. Nicolson, who derived expression for deformation of boiler shell in immediate neighborhood of end plates, and this problem is mathematically identical with that involved in determining width of rim which can be effectively supported by web plate of rotating disk.

DRILLING MACHINES

Piston. Hoefer Production Piston-Drilling Machine. Am. Mach., vol. 64, no. 20, May 20, 1926, p. 805, 1 fig. Machines marketed by Hoefer Mfg. Co., Freeport, Ill., intended for drilling holes for piston pins in cast-iron or alloy pistons.

Portable. Portable Drilling Machines. Machy. (Lond.), vol. 28, no. 709, Apr. 29, 1926, pp. 144–147, 7 figs. Application to locomotive and heavy engineering work; types made at Selson Eng. Co., London.

Railway Shops. The Drilling Machine in the Railway Shop, L. R. Gurley. Ry. Mech. Engr., vol. 100, no. 6, June 1926, pp. 351–358, 25 figs. Requirements for efficient operation; jigs fixtures and practical setups.

DROP FORGING

Metals. Drop Forging Metals, D. Forger. Metal Industry (N. Y.), vol. 24, nos. 4, 5 and 6, Apr., May and June 1926, pp. 141–142, 183–184 and 242–243, 1 fig. Describes British practice. Apr. and May: Aluminum alloys; importance of temperature control; types of furnace; design problems; dies; heat treating; machining and finishing; precautions in handling. June: Copper and brass.

DURALUMIN

Constituents, Replacement of. Compensated Aluminum Alloys (Vergütbare Aluminiumlegierungen), W. Kroll. Metall u. Erz, vol. 23, no. 9, 1st May no., 1926, pp. 225–230. Discusses effect of replacement of constituents of duralumin by other metals; tests on replacement of magnesium by other silicide-forming metals, showing that none of these could be successfully substituted for magnesium in duralumin.

Working. Some Notes on Working Duralumin. Machy. (Lond.), vol. 28, no. 705, Apr. 1, 1925, pp. 15–16. Practical hints on its heat treatment, machining, riveting and welding.

E

EDUCATION, ENGINEERING

Evolutionary Trends. Evolutionary Trends in Engineering Curricula, W. E. Wickenden. Jl. Eng. Education, vol. 16, no. 10, June 1926, pp. 658–668, 8 figs. Presents diagrams indicating general trends in evolution of engineering curricula during past fifty years.

General Education. The Engineering Course as a General Education, E. W. Whited. Jl. Eng. Education, vol. 16, no. 9, May 1926, pp. 615–620. Points out that engineering course is being recognized more and more as excellent system for general education; principal explanation of this fact is that type of mental training given in engineering course fits man for large number of vocations in life, even outside of engineering.

Mechanical Engineering. Graduation Requirements in Mechanical Engineering, W. C. John. Jl. Eng. Education, vol. 16, no. 9, May 1926, pp. 581–601, 3 figs. Summary and analysis of graduation requirements in mechanical engineering; comparison of graduation requirements in publicly and privately supported institutions.

University of Cincinnati. Engineering College Renders Six Distinct Services to Industry, E. J. Mehren. Eng. News-Rec., vol. 96, no. 23, June 10, 1926, pp. 936–939, 1 fig. Integrated service at University of Cincinnati; included are raw-materials survey, industrial and basic research, and training of students in commerce and applied art.

ELECTRIC DRIVE

Box Factory. Motor Driving Problems in Box Factory. Elec. World, vol. 87, no. 20, May 15, 1926, pp. 1043–1045, 5 figs. Power requirements; basic reasons for determining selection of motors for individual or group applications; trend toward driving.

Group vs. Individual. Group vs. Individual Drive. Elec. World, vol. 87, no. 25, June 19, 1926, pp. 1342. Views of four engineers who have had considerable contact with industrial practices; factors to consider in adopting one drive or other, or combination.

ELECTRIC FURNACES

Resistance. Electric Conditions for Resistance-Furnace Operation (Le condizioni elettriche di funzionamento dei forni a resistenza), G. Rebora. Elettrotecnica, vol. 13, no. 7, Mar. 5, 1926, pp. 137–141, 19 figs. Discusses electric phenomena in resistance furnaces and monophase a.c. operation, for production of carbide, ferroalloys, abrasives, etc.; develops calculations for principal elements.

Wire and Ribbon Wound Resistance Furnaces, C. C. Bidwell. Optical Soc. of America & Rev. Sci. Instruments—Jl., vol. 12, no. 5, May 1926, pp. 495–502. Furnace constructed with core tube 18 inches long and $1^1/_4$-inch bore upon which resistor wire or ribbon is wound with $^1/_{16}$-inch clearance between windings will give 6-inch uniform temperature chamber, if ends are plugged tightly with granular alundum for 2 inches; molybdenum furnaces, and current and voltage requirements and regulation.

Rotary. Electric Rotary Furnaces Prove Highly Successful, I. S. Wishoski. Fuels & Furnaces, vol. 4, no. 6, June 1926, pp. 683–688, 4 figs. Automobile parts accurately carburized in three large rotary furnaces; smaller rotary furnace gives excellent results in heat treating ring gears.

ELECTRIC LOCOMOTIVES

France. Express Electric Locomotives for the Midi Railway Company of France. Engineering, vol. 121, no. 3150, May 28, 1926, pp. 622–625, 6 figs. Locomotives built at Tarbes Works of Constructions Electriques de France for Midi Railway; design embodies 3 pairs of driving wheels; power is transmitted through springs.

Germany. Electric Main-Line Locomotives at the German Traffic Exposition of Munich, 1925 (Die elektrischen Vollbahnlokomotiven auf der Deutschen Verkehrausstellung München 1925), G. Lotter and A. Wichert. Organ für die Fortschritte des Eisenbahnwesens, vol. 81, no. 6, Mar. 30, 1925, pp. 109–120, 18 figs. Design and equipment of various types for passenger and freight traffic; increased use of standardized parts.

High-Speed. High Speed Electric Locomotives. Int. Ry. Congress—Bul., vol. 8, no. 5, May 1926, pp. 431–459. Discussion by section and at general meeting.

ELECTRIC RAILWAYS

Illinois. From Receivership to Prosperity in Three Years. Elec. Ry. Jl., vol. 67, nos. 9, 10, 11 and 14, Feb. 27, Mar. 6, 13 and Apr. 3, 1926, pp. 357–362, 393–395, 439–443 and 593–595, 19 figs. Feb. 27: Development of territory, reconstruction of track and operation of new cars on Chicago, Aurora & Elgin Railroad have increased transportation revenue 65 per cent in three years. Mar. 6: Substitution of limestone for gravel ballast; additional crossing protection installed; block signals. Mar. 13: All-steel, 51-ton, 58-passenger cars; shop facilities increased. Apr. 3: Savings made in cost of power generation; 3 new substations built.

Skokie Valley Route Gives North Shore Line Widened Territory and Improved Facilities. Elec. Ry. Jl., vol. 64, no. 25, June 19, 1926, pp. 1043–1048, 9 figs. $10,000,000 high-speed cutoff at Chicago, North Shore & Milwaukee R. R., represents economical combination of railroad and power-line right-of-way, catenary overhead construction, full automatic substations with supervisory control, modern all-electric interlocking plants and high-speed roadbed provided on $22^1/_2$-mile new route.

Traction Recorders. Improved Instrument for Car Operation Tests, A. W. Swan. Elec. Ry. Jl., vol. 67, no. 20, May 15, 1926, pp. 845–846, 5 figs. Improved traction recorder charts five individual records, namely, line voltage, station stops, total current, brake applications and speed in miles per hour.

ELECTRIC WELDING, ARC

Copper Castings. Arc Welding Heavy Copper Castings, P. M. Rauscher. Welding Engr., vol. 11, no. 5, May 1926, pp. 17–18, 5 figs. How copper blast-furnace castings are repaired by metallic arc process; work has to be kept hot for welding.

Portable Plant. A Portable Arc-Welding Plant. Engineer, vol. 141, no. 3672, May 28, 1926, p. 562, 4 figs. Portable arc-welding and cutting plant, made by Siemens Schuckert; welding generator, motor-starting and regulating apparatus and instruments are all contained in single housing, which is waterproof, and plant is claimed to be specially suited for outdoor work.

ELEVATORS

Equipment. High-Speed Alternating-Current Elevator Equipment, E. Thurston. Power, vol. 63, no. 22, June 1, 1926, pp. 848–849, 3 figs. Non-sealing type of magnet, built like polyphase induction motor, is applied to operating controller contractors and brake; multi-speed squirrel-cage motors are used having speed ratios as high as six to one.

Office-Building Equipment. Elevator Equipment in a large Office Building, C. R. Callaway. Power, vol. 63, no. 25, June 22, 1926, pp. 956–959, 7 figs. Elevator equipment of Equitable Life Assurance Society's 22-story building in New York City; there are 29 elevators of which 24 are in regular passenger service; machines are of 1 : 1 gearless-traction type and have modified form of variable-voltage control.

Stops, Probable Number of. Note on the Probable Number of Stops Made by an Elevator, B. Jones. Gen. Elec. Rev., vol. 29, no. 6, June 1926, pp. 425–426, 1 fig. Re-study of formulas presented in Aug. 1923, issue of same journal.

F

FANS

Resistance. Resistance in Fan Engineering, O. Stott. Colliery Eng., vol. 3, no. 26, Apr. 1926, pp. 177–182, 21 figs. Author tries to analyze what should be meant by resistance and also how it may be conveniently measured and indicated.

FLOW OF AIR

Pipes. A Thermionic Valve Method of Measuring the Velocity of Air-Currents of Low Velocity in Pipes, J. A. C. Tergan. Lond., Edinburgh & Dublin Philosophical Mag. & Jl. Sci., vol. 1, no. 5, May 1926, pp. 1117–1120, 1 fig. Describes hot-wire anemometers of new type which has been found satisfactory for measurement of slow-moving streams of air in pipes.

Research. Tasks of Air Flow Research, L. Prandtl. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 365, June 1926, 11 pp. Describes tasks of Kaiser Wilhelm Institute for Air Flow Research, which is dedicated first of all to systematic study of phenomena of flow in contradistinction from other institutes. Translated from Naturwissenschaften, vol. 14, no. 16.

FLOW OF FLUIDS

Stationary Flow. A Special Case of Stationary Flow of Fluids (Ein spezieller Fall staionärer Flüssigkeitsströmung aus dem Gebiete der Wärmekonvektion), B. Gündel. Zeit. für angewandte Mathematik u. Mechanik, vol. 6, no. 2, Apr. 1926, pp. 112–117, 2 figs. Calculation of peculiar flow phenomenon discovered by author in his investigation of problem of heat convection; this special case of stationary flow is brought about by inconstancy of mass density due to temperature distribution under influence of gravity acceleration, showing, therefore, simultaneous action of heat conduction and convection.

Viscous Fluids. The Motion of Two Spheres in a Viscous Fluid, M. Stimson and G. B. Jeffery. Roy. Soc.—Proc., vol. 3, no. A757, May 1, 1926, pp. 110–124, 2 figs. Determination of motion set up in viscous fluid at rest at infinity by two solid spheres (equal or unequal) moving with equal small constant velocities parallel to their line of centers; solution is based on determination of Stokes' stream function for motion of fluid, and from this, forces necessary to maintain motion of spheres are calculated.

FLOW OF WATER

Kinetographic Flow Pictures. Kinetographic Flow Pictures, L. Prandtl and O. Tietjens. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 364, May 1926, 6 pp., 12 figs. According to method worked out by F. Ahlborn, flow of water can be photographed by strewing on its surface fine par-

ticles and making short time exposures; each particle travels certain distance during exposure and is photographed as short straight line; total of all these short lines produces picture which shows direction of flow at every point and also its velocity; describes device employed by authors to make such pictures. Translated from Naturwissenschaften, vol. 13.

Measurement. Flow of Water In Steep Channels with Special Reference to Automatic Mixing with Air [Wasserbewegung in steilen Rinnen (Schusstennen) mit besonderer Berücksichtigung der Selbstbelüftung], R. Ehrenberger. Zeit. Oesterr. Ingenieur u. Architekten Vereines, vol. 78, nos. 15–16 and 17–18, Apr. 16 and 30, 1926, pp. 155–160 and 175–179, 20 figs. Results of tests carried out to determine flow in conduits with gradient of up to 70 per cent; layer of water and air mixture; photographic measurement of surface velocity; average profile velocities; comparison of results; additional remarks on mixing of air and water during flow.

Reducing the Formulas Most Generally Used for Calculating Channels and Conduits to a Monomial Form (Riduzione a forma monomia delle formole piu frequentemente usate per il calcolo dei canali e delle condotte), F. Contessini. Annali dei Lavori Pubblici, vol. 64, no. 1, Jan. 1926, pp. 15–25, 4 figs. Reduces formulas by Darcy, Bazin and Kutter and their derivatives to common equation, and gives table for coefficient of roughness, etc.

Pressure Conduits. Gaging Flow in Pressure Conduits (Jaugeages au moulinet dans les conduites forcées), H. Dufour. Bul. Tech. de la Suisse Romande, vol. 52, no. 9, Apr. 24, 1926, pp. 102–108, 6 figs. Method and apparatus for measuring velocity of water at any point of conduit diameter by means of hydrometric propeller stationed at known points, gives examples of successful application in Norway, Spain, Switzerland.

FLYING BOATS

Development Trend. The Trend of Flying Boat Development, H. C. Richardson. Am. Soc. Nav. Engrs.—Jl., vol. 38, no. 2, May 1926, pp. 231–253, 13 figs. Model basin tests; "V" bottoms; hydrovanes or blades; conclusions.

FLYWHEELS

Manufacture. Two Methods of Making Flywheels, F. H. Colvin. Am. Mach., vol. 64, no. 21, May 27, 1926, pp. 821–823, 8 figs. Fixtures and methods used in making both Hupp and Stutz flywheels; machines used in turning, drilling and balancing wheels.

FOREMEN

Training. Foremen Training is Essential to Plant Self-Government, C. McCormick, Jr. Am. Mach., vol. 64, no. 22, June 3, 1926, pp. 863–864. Prime object of foreman training is to obtain correct application of company policies; influence of foremen on production, quality and cost; promotion within ranks.

FORGING

Factors. Some Factors in Forging Steel, O. W. Ellis. Forging—Stamping—Heat Treating, vol. 12, no. 5, May 1926, pp. 158–163, 9 figs. Deals with factors affected by forging machine and those affected by material being forged.

FOUNDRIES

Automobile Plants. How New Equipment Helped Triple Output in an Auto Foundry, P. Dwyer. Foundry, vol. 54, no. 11, June 1, 1926, pp. 418–422 and 444, 8 figs. Methods and equipment of gray-iron foundry of General Motors Corp. in Saginaw, Mich.

Electric Steel. Foundry Has Electric Ovens. Iron Age, vol. 117, no. 24, June 17, 1926, pp. 1703–1707, 4 figs. Completeness of electrical application is feature of Ross-Meehan steel foundries; core drying and annealing is done electrically; hard-iron grinding in malleable plant.

Ingot-Mold. First Ingot Mold Foundry in West, R. A. Fiske. Iron Age, vol. 117, no. 23, June 10, 1926, pp. 1642–1644, 7 figs. Careful centering of core bar in core box, pattern in flask and core in mold insure uniform wall thickness in ingot mold; methods and equipment of foundry at South Chicago, Ill. See also description in Iron Trade Rev., vol. 78, no. 23, June 10, 1926, pp. 1499–1501, 7 figs.

Machine Shops, Coöperation with. Machine Tools and Foundry Practice. Metallurgist (Supp. to Engineer, vol. 141, no. 3672). May 28, 1926, p. 67. Consideration of facts suggests that adoption of grinding methods for treatment of castings, combined with casting much closer to dimensions in foundry offers method of economy which engineers and foundrymen together should consider most carefully.

Materials Handling in. Determining and Reducing Cost of Materials Handling in Iron Foundries (Die Förderkosten in Eisengiessereien und die Möglichkeiten ihrer Verringerung), K. Hoffmeister. Fördertechnik u. Frachtverkehr, vol. 19, nos. 8 and 9, Apr. 16 and 30, 1926, pp. 109–114 and 131–134, 13 figs. Discusses costs of materials handling and how to determine them; cost and upkeep of conveyors, cranes, etc.; cost of materials handling in relation to cost of production; reducing cost by suitable machinery, overhead cableways, etc.; comparison of costs with variation in production.

Practice. Modern Foundry Practice (Der neuzeitliche Giessereibetrieb), L. Zerzog. Giesserei-Zeitung, vol. 23, nos. 6, 7 and 8, Mar. 15, Apr. 1 and 15, 1926, pp. 147–153, 179–186 and 213–219, 70 figs. Training of apprentices and engineers; specialization; innovations; waste utilization; economic utilization of by-products; flask problems; jarring machines, sand handling; flaskless molding machines; electric trucks for materials handling; cupola operation; cast iron with pearlitic structure; Thyssen-Emmel process; melting with 100-per cent steel scrap; Wüst patented oil furnace; electric furnaces; Söderberg electrodes; Bosshardt furnaces.

FUELS

Garbage as. Utilization of Municipal Garbage as Fuel (Das städtische Müll als Brennstoff), H. Koschmieder. Wärme, vol. 49, no. 12, Mar. 19, 1926, pp. 207–210, 4 figs. Calorific value of garbage; Dörr, Herbertz, cascade-grate and Humboldt systems of combustion.

Gaseous. Industrial Fuels, H. H. Clark. Engrs'. Soc. West. Pa.—Proc., vol. 42, no. 2, Mar. 1926, pp. 100–108 and (discussion) 109–118, 7 figs. Principal gaseous fuels are natural, city and producer gas; use of city gas in Chicago.

Heating Value. Calorimetric Determinations of the Heating Value of Fuels, W. J. Wohlenberg. Combustion, vol. 14, no. 5, May 1926, pp. 317–319, 1 fig. Their exact relation to energy releasable in boiler furnace.

[See also COAL; LIGNITE; OIL FUEL; PEAT; PULVERIZED COAL.]

FURNACES, HEAT-TREATING

Salt-Bath. Design and Use of Salt Bath Furnaces, M. Epstein. Machy. (N. Y.), vol. 32, no. 10, June 1926, pp. 787–789, 9 figs. Main considerations in salt-bath furnace design; heat treatment of high-speed steel in "Lavite" bath; comparison between "Lavite" and lead-heating baths.

FURNACES, HEATING

Reheating. Re-Heating Furnaces, F. G. Bell and R. Waddell. Iron & Coal Trades Rev., vol. 112, nos. 3032 and 3033, Apr. 9 and 16, 1926, pp. 609–610 and 648–650, 12 figs. Results of experiments carried out by Brown, Bayley's Works show that they have been able to reduce consumption of fuel re-heating furnaces to a figure as low as, or lower than, can be obtained by any competitive system; that they can operate continuously, except for hour or two at lighting up, with ordinary slack; that just as good results have been obtained in heating of their steel as with any other type of furnace tried; and that latest types of recuperative furnace fired with slack are definitely proved to be practically smokeless in operation.

G

GASES

Ignition. Ignition of Gases by Sudden Compression, H. T. Tizard and D. R. Pye. Lond., Edinburgh and Dublin Philosophical Mag. & Jl. Sci., vol. 1, no. 5, May 1926, pp. 1094–1105, 4 figs. Experiments in which both time and pressures could be measured with greater accuracy than previously; results of typical experiments by which behavior of mixtures of ether and air on compression in old and new apparatus can be compared.

GASOLINE

Anti-Knock. Research Reveals Anti-Knock and Other Qualities of Natural Gasolines, E. H. Leslie and G. G. Brown. Nat. Petroleum News, vol. 18, no. 23, June 9, 1926, pp. 45–50, 13 figs. Tests of straight-run natural gasoline and results obtained. Paper read before Natural Gasoline Mfrs.

GEAR CUTTING

Machines. Maag Gear-Cutting and Gear-Grinding Machines (Die Maag-Zahnradhobelmaschine und die Maag-Stirnradschleifmaschine), K. M. Dolezalek. Maschinenbau, vol. 5, no. 9, May 6, 1926, pp. 402–406, 10 figs. Design and operation of machines; cutting gear teeth by helicoidal cutter; grinding machine uses two plate disks as tool.

GEARS

Ground. Hardened and Ground Gears of High-Grade Steel (Gehärtete und in der Verzahnung geschliffene Zahnräder aus hochwertigem Stahl), H. Hofer. Maschinenbau, vol. 5, no. 8, Apr. 15, 1926, pp. 353–356, 20 figs. Discusses grinding of gear teeth; develops curves showing gear-flange characteristics and defects in form; explains effect of these defects on gear operation and shows necessity for using best grade of material.

Helical. Brown Boveri Gears. Brown Boveri Rev., vol. 13, nos. 2, 3, 4, 5 and 6, Feb., Mar., Apr., May and June, pp. 47–54, 76–83, 102–110, 128–131 and 153–157, 69 figs. Discusses design of single helical and double helical gears and their advantages over spur gears; forced lubrication and oil cooling, using unsaponifiable mineral oil. Apr.: Turbine drives for miscellaneous machines; geared motor drives. May: Gears for marine installations. June: Vertical-shaft gear; gears for other purposes.

Hypoid Rear-Axle. Design, Production and Application of the Hypoid Rear-Axle Gear, A. L. Stewart and E. Wildhaber. Soc. Automotive Engrs.—Jl., vol. 18, no. 6, June 1926, pp. 575–580 and 600, 8 figs. After defining hypoid gears and outlining their action, characteristics and advantages, authors compare them specifically with spiral-bevel gears and describe how axis of pinion is offset from axis of gear and how direction of offset determines whether spiral is right-handed or left-handed; newest method for producing hypoid gears; finish-cutting of pinion is only major operation which requires machinery different from that used for spiral-bevel gears and pinions.

Railway Cars. High Standard of Bearing Maintenance Gives Long Life, A. E. Roberts. Elec. Ry. Jl., vol. 64, no. 25, June 19, 1926, pp. 1051–1052, 6 figs. After average service of 595,000 miles per gear, maximum tooth wear found was 0.008 in. and majority showed wear between 0.002 in. and 0.005 in. on electrified lines of Southern Railway, England.

Silent. Greater Economy in Present Method of Fabricating Silent Gears, H. R. Moyer. Automotive Industries, vol. 54, no. 22, June 3, 1926, pp. 934–937, 13 figs. Waste is largely eliminated by cutting material into small segments and molding to form annulus; new development is pressed steel center; centers of molded material also used; development of Micarta gear.

Spur. Method of Calculating Spur Gearing (Beitrag zur Berechnungsweise der Stirnzahnräder), E. Videky. Maschinenbau, vol. 5, no. 8, Apr. 15, 1926, pp. 362–365, 4 figs. Shows errors in present method of calculation based on the work of Bach and proposes new simple method to find length of teeth.

Teeth, Wear of. The Relation of Load to Wear on Gear Teeth, E. Buckingham. Am. Mach., vol. 64, no. 20, May 20, 1926, pp. 777–780, 2 figs. Experiments show that in order to transmit power without appreciable wear, maximum specific stress given by Hertz equation should not exceed elastic limit. Paper presented before Am. Gear Mfrs.' Assn.

Wear of Gear Teeth, E. Buckingham. Machy. (N. Y.), vol. 32, no. 10, June 1926, pp. 798–799. Maximum loads that do not produce too rapid wear; investigations of gear drives for durability; formula and constants for determining maximum safe load and example of use of formula and tables. (Abstract.) Paper presented before Am. Gear Mfrs.' Assn.

Worm. The Automotive Worm-Gear, L. R. Buckendale. Soc. Automotive Engrs.—Jl., vol. 18, no. 6, June 1926, pp. 649–654, 16 figs. Outlines progress in development; enumerates advantages of worm drive; freedom from knock is attributed to obliquity of approach of teeth to greater areas in contact, and to low resonant qualities of materials used.

GLUES

Research. Adhesives and Adhesive Action. Engineering, vol. 121, nos. 3152 and 3153, June 11 and 18, 1926, pp. 700–701 and 737–738, 17 figs. Results of several investigations on adhesives to aid in placing manufacture and use on satisfactory basis; investigations included study of chemistry of gelatins, nature of adhesion, and methods of testing adhesives.

GRINDING

Centerless. Grinding Sewing Machine Shafts on the Centerless Grinding Machine, H. Densmore. Am. Mach., vol. 64, no. 21, May 27, 1926, pp. 813–815, 5 figs. Accurate grinding of shafts with keyways at end; shafts ground to 0.002-in. oversize before keyway is cut; shafts straightened after hardening; automatic feeding device.

GRINDING MACHINES

Automatic. Double-Acting Automatic Grinding Machines with Pressure Regulation (Doppeltwirkende selbsttätige Schleifmaschine mit Schleifdruckregulierung), Praktische Maschinen-Konstrukteur, vol. 89, no. 15–16, Apr. 17, 1926, pp. 148–150, 2 figs. Universal grinding machine for grinding surfaces and various types of gears for machine tools, of very simple construction and economic operation, built by Grossenhain Machine Works Co.

Disk. Disk-Grinding on Production Work, W. F. Sandmann. Machy. (N. Y.), vol. 32, no. 10, June 1926, pp. 800–801, 7 figs. Double-end disk grinder; automatic grinder.

Hob and Cutter. Hob and Cutter Grinder for the Tool Room. Ry. Mech. Engr., vol. 100, no. 6, June 1926, pp. 383–384, 1 fig. New machine introduced by Pratt & Whitney Co. for general use in sharpening gear hobs, thread hobs, form milling cutters, etc.

H

HAMMERS

Electropneumatic. 30-Cwt. Power Hammer. Engineer, vol. 141, no. 3671, May 21, 1926, pp. 533–534, 2 figs. Electropneumatic hammer of overhanging type, with arch form of frame, made by B. & S. Massey.

HEAT

Radiation, Entropy of. On Entropy of Radiation, M. Saha and R. Kanto Sur. Lond., Edinburgh & Dublin Philosophical Mag. & Jl. Sci., vol. 1, no. 4, Apr. 1926, pp. 890–893. Develops theorem which shows that if radiation is used as working substance, absolute zero can be attained in space where all radiation has been completely annihilated.

HEAT TRANSMISSION

Coefficients for Refrigeration. Vital Heat Transfer Data for the Refrigerating Engineer, H. J. Macintire. Power, vol. 63, no. 22, June 1, 1926, pp. 857–858. Heat-transfer action; transfer in counter-current condensers; advantage of shell-and-tube type; coefficients in other apparatus.

Research. Some Results of Heat Transmission Research, F. B. Rowley. Am. Soc. Heat. & Vent. Engrs.—Jl., vol. 32, no. 5, May 1926, pp. 339–348 and 374, 12 figs. Relates progress made at University of Minnesota.

HEAT TREATMENT

Electric, Norway Iron. Electric Heat Treatment of Norway Iron. Ry. Signaling, vol. 19, no. 6, June 1926, p. 242, 1 fig. Magnetic circuit of signal relay is composed of parts made up of soft Norway iron; Union Switch & Signal Co. uses Westinghouse pit-type electric furnace for heat-treating process to obtain accurate temperature control and uniformity of heating.

HEATING

Humid-Air. Humid Air as a Heating Medium, F. Brown. Am. Soc. Heat. & Vent. Engrs.—Jl., vol. 32,

no. 5, May 1926, pp. 331-338, 5 figs. Presents data showing how humid air as heating medium accomplishes primary object of development, economy of operation, by reducing steam consumption for comfortable heat; and secondary object, lesser temperature differential between floor and ceiling temperatures, or comfortable knee-height temperature by operation of radiator at temperatures lower than is possible in conventional steam installation.

HEATING, ELECTRIC

Industrial Load. A Few Suggestions for Developing Industrial Heating Load, E. Fleischmann. N. E. L. A. Bul., vol. 13, no. 4, Apr. 1926, pp. 219-222. Suggests methods of developing and retaining good will of customers toward electric heat.

Industrial Plants. Factors that Determine When Electric Heating Can Be Used to Advantage, W. S. Scott. Indus. Engr., vol. 84, no. 6, June 1926, pp. 272-275, 4 figs. Discussion of operating economies and desirable features that are inherent in this mode of heating.

HEATING, HOT-WATER

Industrial Plants. How Forced Hot Water System Heats Ford's Twin Cities Plant, E. H. Whittemore. Plumbers' Trade Jl., vol. 80, no. 10, May 15, 1926, pp. 968-969 and 983, 5 figs. Heat is supplied from steam power plant located at river bank and about 300 ft. away from building; water-heating equipment and piping system are so arranged that office section of building may be operated separately from rest of building.

HEATING, STEAM

Central. Central Heating Plant of the Berlin Technical High School (Das Kraftfernheizwerk der Technischen Hochschule Berlin), Kuhberg. Zentralblatt der Bauverwaltung, vol. 46, no. 18, May 5, 1926, pp. 217-221, 11 figs. Layout and operation of steam heating plants, also utilizing exhaust steam, and serving number of government buildings; transmission lines and distribution.

Museums. Heating a Mammoth Museum, E. W. Riesbeck. Domestic Eng. (Chicago), vol. 115, no. 6, May 8, 1926, pp. 26-28, 31-32 and 66, 11 figs. Heating system employed in Field Museum in Chicago; entire building is heated by vacuum system, steam being generated in power plant located in basement; supply lines, risers and branches, general layout of risers and radiators; how it is possible to heat entire building with vacuum and maintain even temperature.

HIGH-SPEED STEEL

Magnetic Analysis. Report of Committee A-8 on Magnetic Analysis. Am. Soc. Testing Matls.—Preprint, no. 15, for mtg. June 21, 1926, 36 pp., 28 figs. Appendix contains article by T. Spooner, presenting results of investigation of correlation between magnetic and electrical properties and heat treatment of series of bars of high-speed steel; considers various testing methods.

HYDRAULIC TURBINES

Pitting of Runners. Pitting of Hydraulic Turbine Runners. Power Plant Eng., vol. 30, no. 12, June 15, 1926, pp. 704-705, 1 fig. Total draft head forms greatest single factor in determining its absence or occurrence. (Abstract.) Subcommittee report before Nat. Elec. Light Assn.

Stream-Flow. Stream-Flow Turbines (Die Lösung des Stromturbinenproblems durch E. Suess), E. Pucher. Elektrotechnik u. Maschinenbau, vol. 44, no. 17, Apr. 25, 1926, pp. 313-317, 4 figs. Describes Suess turbine which, it is claimed, solves completely problem o stream-flow turbine; tests in Danube with Suess turbine having casing of 59-in. diam. at smaller end and 78½-in. diam. at outlet, showed efficiency of 74 per cent; author shows that there is no likelihood of trouble from cavitation at any velocities encountered in practice; it is particularly economical where swift streams are concerned. See also brief translated abstract in Power Engr., vol. 21, no. 243, June 1926, pp. 232-233.

HYDROELECTRIC DEVELOPMENTS

California. Bucks Creek Project of the Feather River Power Company on North Fork of Feather River, California, C. W. Faries. West. Constr. News, vol. 1, no. 4, Feb. 25, 1926, pp. 28-33, 1 fig. Details of highest head hydroelectric power plant yet constructed in United States; initial capacity of main storage reservoir will be 103,000 acre ft.

Kings River Development of the San Joaquin Light & Power Corporation, H. K. Fox. West. Constr. News, vol. 1, no. 8, Apr. 25, 1926, pp. 15-24, 11 figs. Project consists of 4 reservoirs with total capacity of 306,000 acre ft., 9 power plants, 14 dams of various types, and about 40 miles of conduit, most of last being pressure tunnels.

France. Water-power for the Paris-Orleans Railway Electrification, M. Parodi. Engineer, vol. 141, no. 3673, June 4, 1926, pp. 584-585. Information regarding sources of water power which are to be utilized for that purpose; dam on Creuse River; power station of Coindre. Translated abstract from Revue Générale des Chemins de Fer.

Quebec. Development Work at Chelsea and Farmer's Rapids on the Gatineau, A. H. White. Contract Rec., vol. 40, no. 20, May 19, 1926, pp. 462-464, 4 figs. Four principal points for development at Maniwaki, Paugan Falls, Chelsea and Farmers Rapids; two latter are now in process of development.

St. Lawrence River. Water Power Development on the St. Lawrence River, F. P. Williams. Cornell Civ. Engr., vol. 34, no. 8, May 1926, pp. 199-201 and 214, 3 figs. Power development of river is definitely involved with proposed improvement for navigation; average flow of river; channels across which dams are to be built vary from one-half to about one mile in width; status of St. Lawrence project.

HYDROELECTRIC PLANTS

Automatic. Automatic Non-Governing Hydro Plant, C. P. Scheller and W. B. Carr. Elec. World, vol. 87, no. 24, June 12, 1926, pp. 1285-1288, 4 figs. Self-operating features and elimination of governor favor development of water-power site with economy in regard to both first cost and cost of operation; complete tests gave satisfactory results.

Great Britain. The New Hydraulic Power Station at Cardiff Docks. Engineering, vol. 121, nos. 3148 and 3150, Apr. 30 and May 28, 1926, pp. 554-556 and 562, and 617-619, 16 figs., partly on supp. plate. Work of converting old steam station into electrically operated station making use of high-speed centrifugal pumps; main pumps are each capable of delivering 800 gal. per min. at pressure of 800 lb. per sq. in.; electric supply is brought into pumping station by 2 feeders at 6600 volts, 3-phase, 50 cycles per sec.; pump motors, controllers, protective devices, etc.

Oregon. Oak Grove Power Plant of the Portland Electric Power Co., M. E. Reed. West. Constr. News, vol. 1, no. 7, Apr. 10, 1926, pp. 20-24, 6 figs. Plant constructed at Clackamas River about 55 miles southeast of Portland; it has highest head direct-acting turbine in the world, being under 875 ft. effective head, developing 35,000 hp. with 400 sec. ft. flow; Oak Grove dam is 68 ft. high and 180 ft. long and is concrete arch dam of ordinary ogee section.

Tests. Tests at Wilson Dam Power-House, F. H. Kohloss. Military Engr., vol. 18, no. 99, May-June, 1926, pp. 184-187, 5 figs. Results of tests of 30,000-hp. I. P. Morris-Westinghouse vertical-type unit; flow of water by Weir and by Gibson method, and comparison of two methods; tests would indicate that Gibson test is 95 per cent more economical than Weir test.

I

INDICATORS

Mean-Pressure. Mean-Pressure Indicator (Mitteldruckindikator), G. Geiger. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 15, Apr. 10, 1926, pp. 509-512, 16 figs. Points out that with all reciprocating engines a simple relationship exists between mean piston-stroke and mean piston-time pressure; describes instrument which gives and records both pressures directly.

INDUSTRIAL MANAGEMENT

Budgetary Control. Budget Plan of Liquid Carbonic Company, W. J. Graham. Mfg. Industries, vol. 11, no. 6, June 1926, pp. 425-430, 1 fig. Construction and enforcement of comprehensive budgetary program.

Financial and Industrial Investigation. Operating and Turnover Ratios, A. Andersen. Mfg. Industries, vol. 11, no. 6, June 1926, pp. 441-444. Study of turnover ratios, which as a whole expresses relationship between operating results and capital employed, in other words, comparison between profit-and-loss figures and balance-sheet figures.

Inventory Control. The Control of Inventory Through the Scientific Determination of Lot Sizes, H. S. Owen. Indus. Mgmt. (N. Y.), vol. 71, no. 6, June 1926, pp. 362-365, 4 figs. Condensed reports for executive control.

Labor Attitude Toward. The American Labour Movement and Scientific Management, P. Devinat. Int. Labour Rev., vol. 13, no. 4, Apr. 1926, pp. 461-488. Discusses reasons for earlier opposition of trade units to scientific management, events which gradually led to its breakdown, and steps by which American Federation of Labor came to adopt its present attitude of readiness to collaborate with management in enlightened application to industry of scientific methods of organization.

Maintaining Improved Methods. Keeping Up Improved Operating Results, J. A. Piacelli. Mfg. Industries, vol. 11, no. 6, June 1926, pp. 435-439, 8 figs. Measures taken to maintain results accomplished at Maurer Plants of Barber Asphalt Co.

Manufacturing Control. Timely Guide to Manufacturing Control, J. H. Barber. Mfg. Industries, vol. 11, no. 6, June 1926, pp. 417-420, 4 figs. Describes valves and fittings index of Walworth Co.; its general significance and methods employed.

Obsolescence, Measure of. Obsolescence, L. L. Thwing. Jl. of Accountancy, vol. 41, no. 5, May 1926, pp. 321-329. Discusses following points: (1) Is measure of obsolence technical or economic? (2) Is obsolescence fundamentally general or specific? (3) How is spread to be determined?

Planning and Routing. Planning and Routing Shop Work, J. S. Gray. Machy. (N. Y.), vol. 32, no. 10, June 1926, pp. 776-778. General duties of planning department; effect of planning on costs and on delivery dates; details of work of planning department; coöperation between shop and planning department.

Sales Program. A Market Survey and Its Results, H. L. Keely. Mfg. Industries, vol. 11, no. 6, June 1926, pp. 421-424, 3 figs. Method of applying market survey for increasing sales of building material.

INDUSTRIAL PLANTS

Power-Factor Maintenance. Power Economy in Industrial Plants (Betriebstromwirtschaft), F. Rieser. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 20, May 15, 1926, pp. 656-658, 3 figs. Presents polar diagram showing necessity of and profits derived from maintenance of high power factor.

Power Analysis. The Rewards to Management from a Real Analysis of Power, D. M. Myers. Factory, vol. 36, no. 5, May 1926, pp. 830-835, 870, 874, 876, 978 and 980, 12 figs. Frank discussion of question of purchased versus generated power, with reports on marked improvements in operation which have come from wide contact with industrial-plant problems.

INDUSTRIAL RELATIONS

Conciliation. Simplified Procedure in the Administration of Justice: The Danish Conciliation System, R. H. Smith. Monthly Labor Rev., vol. 22, no. 5, May 1926, pp. 40-49. Method of conciliation possesses substantial merit and can be made to play highly important part in administration of justice; experience of Denmark has been that conciliation can be entrusted to and will be successfully conducted by lay commissions in rural districts; in cities conciliation is best entrusted to judges in regular courts.

INDUSTRIAL TRUCKS

Control. Control Equipment for Industrial Trucks, R. B. Hunter. Indus. Engr., vol. 84, no. 5, May 1926, pp. 219-224, 11 figs. Discusses proper types of controllers to be employed with battery-propelled industrial trucks and locomotives; graphs and diagrams that will aid in selecting type best suited to operating conditions.

Electric. Field of Application and Savings Effected by Industrial Trucks, H. J. Payne. Elec. World, vol. 87, no. 24, June 12, 1926, pp. 1292-1294, 2 figs. Description of operations and uses in various manufacturing plants where electric tractor has proved to be both economical and labor-saving feature.

Lift Trucks. Lift Trucks Revolutionize Handling Costs. Factory, vol. 36, no. 5, May 1926, pp. 842-845, 952, 956, 960, 964, 968 and 972, 5 figs. Cost report on experiences of typical lift-truck users.

Paper Mills. Cutting Handling Costs with Electrical Trucks. Paper Trade Jl., vol. 82, no. 23, June 10, 1926, pp. 59-63, 6 figs. Applications of electric trucks in various mills. (Abstract.) Paper presented before Am. Pulp & Paper Mill Supts.' Assn.

INSULATION, HEAT

Problems. Heat Insulation, C. F. Wade. Elec. Times, vol. 69, no. 1802, Apr. 29, 1926, pp. 543-544, 1 fig. Points out need of continuous attention in order to maintain non-conducting coverings in efficient condition.

INTERNAL-COMBUSTION ENGINES

Detonation. The Effect of Metallic Sols in Delaying Detonation in Internal Combustion Engines, C. J. Sims and E. W. J. Mardles. Engineering, vol. 121, no. 3154, June 25, 1926, pp. 774-776. Describes experiments dealing with effect on detonation of small additions to liquid fuel of certain metals in colloidal form, with view to determining physical and chemical actions that must occur to prevent or control detonation.

Fuel Injection. Fuel Injection, C. Hughes. Inst. Mar. Engrs.—Trans., vol. 37, Apr. 1926, pp. 791-818 and (discussion) 847-860, 17 figs. Discusses new features refering to pumping and injection of liquid fuels into internal-combustion engines; describes functioning of author's latest designs.

Indicator Diagrams. Indicating the High-Speed Multi-Cylinder Internal-Combustion Engine, H. M. Jacklin. Soc. Automotive Engrs.—Jl., vol. 18, no. 6, June 1926, pp. 631-636, 4 figs. Details of construction, application, procedure and operation of standard slow-speed indicator which has been in successful operation for more than 500 hours of testing at Ohio State Univ.; composite indicator diagram obtained over great number of engine cycles which is claimed to be distinct gain over anything else yet tried, since diagram is built up before eyes of testing engineer.

Theory. Evolution of Internal-Combustion Engines, Especially Explosion Engines (L'évolution des moteurs à combustion interne et particulièrement des moteurs à explosion), E. Marcotte. Revue générale des Sciences, vol. 37, no. 7, Apr. 15, 1926, pp. 199-206. Discusses evolution of a fluid in an automobile or airplane engine; development of Diesel engine and Carnot cycle; 4-stroke and 2-stroke engines; combustion; antiknock mixtures.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; OIL ENGINES; SEMI-DIESEL ENGINES.]

IRON ALLOYS

Cementation with Aluminum. Cementation of Ferrous Alloys with Aluminum (La cémentation des alliages ferreux par l'aluminium), J. Cournot. Académie des Sciences—Comptes Rendus, vol. 182, no. 11, Mar. 15, 1926, pp. 696-698; also Revue de Métallurgie, vol. 23, no. 4, Apr. 1926, pp. 219-232, 15 figs. Different methods of cementation were tested, and powdered ferroaluminum process found most satisfactory, ammonium chloride being used as flux; steel low in carbon content was used; variation of efficiency of covering with temperature and time of cementation was tested by heating in oxidizing atmosphere; micrographical examination was also carried out.

IRON AND STEEL

Corrosion. Report of Committee A-5 on Corrosion of Iron and Steel. Am. Soc. Testing Matls.—Preprint, no. 12, for mtg. June 21, 1926, 42 pp., 21 figs. Report of inspection of Fort Sheridan, Pittsburgh and Annapolis tests; total immersion tests; proposed tentative specifications for coating on zinc-coated (galvanized) wire; galvanized iron or steel telephone and telegraph line wire; galvanized iron or steel tie wires; tests of metallic-coated products.

The influence of Alternating Currents on the Electrolytic Corrosion of Iron, A. J. Allmand and R. H. D. Barklie. Faraday Soc.—Trans., vol. 22, part 1, no. 1, no. 64, Jan. 1926, pp. 34-45, 5 figs. Investigates corrosion of iron in alkaline solutions by direct current, alternating current and by alternating current superposed on direct current, and shows that superposition of the two types of current causes relatively increased corrosion; similar result was found when using typical

subsoil drainage liquid saturated with CO_2; experiments were also carried out on accelerating effects of added alkaline chloride on corrosion in alkaline solutions.

L

LATHES

American Automatic. American Automatic Turning Machines, Jos. Horner. Engineering, vol. 121, nos. 3136, 3148 and 3149, Feb. 5, Apr. 30 and May 21, 1926, pp. 181–183, 573–574 and 608–610, 32 figs. Details of Lo-Swing lathe, a machine in which turning is done from front only; Le Blond lathe which is semi-automatic lathe for turning and facing operations only. Apr. 30: Reed-Prentice lathes; automobile-axle lathe. May 21: Fay lathe of double-carriage type; examples of work done.

Centers. Design of Lathe Centers, F. Horner. Machy. (N. Y.), vol. 32, nos. 9 and 10, May and June 1926, pp. 712–716 and 793–797, 16 figs. Typical designs for different classes of work.

Journal-Turning. "Niles" Journal-Turning Lathe, 90-Inch. Am. Mach., vol. 64, no. 23, June 10, 1926, pp. 919–920, 3 figs. Niles-Bement-Pond Co. has built lathe primarily designed for turning and burnishing inside and outside journals, but it can also be arranged for quartering and crankpin turning on locomotive wheels by means of special attachments.

Turret. Warner & Swasey Universal Turret Lathe. Machy. (N. Y.), vol. 32, no. 10, June 1926, pp. 821–823, 4 figs. New 3-A universal turret lathe designed to accommodate both bar and chucking work, and intended for small-lot as well as quantity-production work.

LIGHTING

Textile Mills. Latest Developments in Mill Lighting, R. A. Palmer. Textile World, vol. 69, no. 18, May 1, 1926, pp. 73, 75 and 77, 9 figs. Review of recent progress; tests show that installation of modern lighting in weave shed of dress-goods mill increased production 25 per cent; tests in other mills; studies on vision; inside-frosted lamp; local lighting should only supplement general lighting.

LIGNITE

Steam Generation, Use in. The Economic Use of North Dakota Lignite for Steam Generation, G. B. Wharen. Mech. Eng., vol. 48, no. 6, June 1926, pp. 583–585, 1 fig. Principal deposits; characteristics of North Dakota lignite; firing methods; possibility of utilizing lignite in pulverized form; pulverization; cost of steam production.

LOCOMOTIVE BOILERS

Heat Insulation. Heat Insulation of Steam Locomotives (Der Wärmeschutz bei Dampflokomotiven), Nordmann, Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 22, May 29, 1926, pp. 733–738, 2 figs. Explains successful resistance of locomotive boilers to heat losses; recent tests of German State Railway with spun-glass heat insulation showed slight saving with cooling-off test; points out that tight closing of pistons and valves, good mechanical efficiency as result of careful machining, and maintenance of clean heating surfaces are more important factors than additional heat-protective media.

Pitting and Corrosion. A Study into Causes of Pitting and Corrosion in Locomotive Boilers, W. M. Barr. Ry. Rev., vol. 78, no. 23, June 5, 1926, pp. 977–983, 13 figs. Theory of corrosion; effect of scale on corrosion; effect of air and dissolved gases in water; water treatment; recommendations for reduction in corrosion and pitting.

Wagon-Top Type. Boiler of the Union Pacific Type Locomotive. Boiler Maker, vol. 26, no. 5, May 1926, pp. 123–125, 3 figs. Boiler, designed for 220-lb. working pressure, has largest firebox ever equipped with Gaines arch; it is of wagon-top type.

LOCOMOTIVES

Balancing. Balancing the Effect Produced by Masses in Alternating Motion in Locomotives (Contributo allo studio sul bilanciamento degli effeti prodotti dalle masse dotate di moto alterno nella locomotiva), A. Macchioni. Rivista Tecnica delle Ferrovie Italiane, vol. 29, no. 3, Mar. 15, 1926, pp. 103–116, 13 figs. on supp. plate. Instead of weight of alternating masses, author takes reaction of frame and rails on driving wheels and develops equations which are applied to number of locomotives.

Diesel-Electric. The Diesel-Electric Locomotive and Its Relation to Heavy Electrification. Mech. Eng., vol. 48, no. 6, June 1926, pp. 585–589. Extracts from reports of three addresses given before Metropolitan Sections of four National Engineering Societies in New York City, as follows: Diesel-Electric Locomotive and Its Various Applications, H. Cooke; Diesel-Electric Locomotive, its Field and Advantages, N. W. Storer; Advantages of the Oil-Electric Locomotive Over Electrification on Short-Line and Switching Operations, C. H. Stein; and general discussion.

Electric. See ELECTRIC LOCOMOTIVES.

Freight. 2-8-2 Freight Locomotive, South Australian Railways. Ry. Engr., vol. 47, no. 557, June 1926, pp. 219–220, 1 fig. New types of locomotives built by Armstrong, Whitworth & Co. Ltd., Newcastle-on-Tyne; boiler barrel is of telescopic design; superheater is long loop type with ball-joint attachment to header; cylinders are of American type.

Garratt. Bengal-Nagpur Railway: "Garratt" Locomotives. Engineer, vol. 141, no. 3673, June 4, 1926, p. 586, 2 figs. Engines, delivered by Beyer, Peacock & Co., Manchester, Eng., have tractive effort of 53,500 lb. at 85-per cent boiler pressure; designed for 1500-ton freight trains.

Industrial. Industrial Locomotives. Engineer, vol. 141, no. 3671, May 21, 1926, p. 532, 2 figs. Locomotive with vertical boiler made by Société John Cockerill, Belgium.

Narrow-Gage. New Locomotives for Brazil (Neue Lokomotiven für Brasilien), H. Keller. Zeit. des Vereines deutscher Ingenieure, vol. 70, nos. 19 and 22, May 8 and 29, 1926, pp. 617–622 and 739–741, 38 figs. Details of locomotives for Brazilian railways, showing to what extent narrow-gage railways can approach efficiency of standard-gage operation, when dimensions and performance of locomotives nearly equal that of standard-gage locomotives; Mikado locomotives; Mollet superheater locomotives.

Oil-Electric. Railroads Turning to Heavy Oil Engines for Locomotive Service. Automotive Industries, vol. 54, no. 22, June 3, 1926, pp. 924–925, 3 figs. Power plants of oil-electric type offer advantages of more economical operation reduced maintenance costs, elimination of much capital investment.

The Oil Electric Locomotive in Railroad Service. Can. Ry. Club—Officials Proc., vol. 25, no. 3, Mar. 1926, pp. 20–40, 3 figs. Points out that economies of oil-electric locomotive have been firmly established in past two years in practical demonstrations, and possibilities offered warrant its rapid development to determine extent of its application under present railroad conditions; it offers immediate solution to present costly and objectionable steam operation of yard switching, terminal, branch line and local freight service, where noise and smoke become public nuisance and detrimental to real estate values.

Performance. Steam Locomotive Performance, Theoretical and Actual, M. T. Grime. Ry. Gaz., vol. 44, nos. 21 and 22, May 21 and 28, 1926, pp. 689–690. Locomotive-cylinder performance; effect of superheating on condensation; uniflow engine; restricted cut-off locomotive; locomotive-boiler performance; feedwater heating.

Steam Distribution. Device for Studying Steam Distribution in Locomotives (Apparecchio per lo studio delle distribuzioni delle locomotive a vapore), F. Salvia. Rivista Tecnica delle Ferrovie Italiane, vol. 29, no. 3, Mar. 15, 1926, pp. 94–102, 12 figs. on supp. plate. Device consisting of frame on which locomotive mechanism is reproduced for study, drawing piston and elliptic diagrams, etc.

Thermic Siphons. Nicholson Thermic Siphons for locomotive Fireboxes (Wasserkammern Bauart Nicholson für Lokomotivfeuerbüchsen), E. H. Metzeltin. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 18, May 1, 1926, pp. 593–596, 9 figs. Thermic siphons of this type, used in United States since 1918, result in increasing direct heating surface from 15 to 45 per cent; other advantages and example of their application; German State Railway has decided to carry out tests with these thermic siphons.

Union Pacific Type. Union Pacific Type Locomotive. Ry. Age, vol. 80, no. 24, May 15, 1926, pp. 1295–1300, 10 figs. 4-12-2 design is developed from comparative studies of 2-8-8-0, two-cylinder 2-10-2, and three-cylinder 4-10-2 locomotives; largest non-articulated locomotive constructed thus far. See also descriptions in Ry. Rev., vol. 78, no. 20, May 15, 1926, pp. 857–864, 20 figs.; and Ry. & Locomotive Eng., vol. 39, no. 5, May 1926, pp. 123–129, 14 figs.

LUBRICANTS

Equipment for Applying. Equipment Used for Applying Lubricants, F. E. Gooding. Indus. Engr., vol. 84, no. 5, May 1926, pp. 213–218 and 228, 15 figs. Methods and equipment for applying lubricants continuously or intermittently to different designs of bearings used on machines.

LUBRICATING OILS

Automobile Engines. Tests of Voltol Oils for Lubrication of Automobile Engines (Erprobung der Autovoltole als Schmieröl für Automobilmotoren), G. Becker. Motorwagen, vol. 29, no. 9, Mar. 31, 1926, pp. 187–196, 7 figs. Results of tests on electrically treated lubricating oil manufactured by Stern-Sonneborn A. G. in Hamburg, Germany, now known as Rhenania, Ossag A. G.; tests covered friction losses, power developed, heating of oil, changes in composition and general behavior on road; it was found that Voltol stood up excellently at high load without giving undue friction losses at low load and low speed.

Selection. The Selection of Lubricating Oils for Working Conditions of Bearing Load, Speed and Temperature, G. B. Vroom. Am. Soc. Nav. Engrs.—Jl., vol. 38, no. 2, May 1926, pp. 289–300, 6 figs. For petroleum industry, combined alignment chart and viscosity-temperature diagram which are presented, should be of value in detemining brand and viscosity selection from line of oils to meet specific needs of customers.

Wear. Causes of Changes in Lubricating and Insulating Oils in Use (Beobachtungen über die Ursachen der Veränderung der Schmier- und Isolieröle im Gebrauch), F. Frank. Braunkohle, vol. 25, no. 4, Apr. 24, 1926, pp. 61–66. Discusses fatigue of oils due to action of oxygen and polymerization, examination and analysis of used turbine, transformer and cylinder oils.

M

MACHINE SHOPS

Electric Heat for. Electric Heat for the Machine Shop, P. F. Creasy. Am. Mach., vol. 64, no. 22, June 3, 1926, pp. 865–868, 8 figs. Variety of applications; uniformity of product and better working conditions claimed.

MACHINE TOOLS

Locating Devices. Positive Locating Devices Vital, F. Horner. Can. Machy., vol. 36, no. 22, June 3, 1926, pp. 23–25, 19 figs. Points out that vital factor in design and operation of machine tools and other machinery is facility with which parts can be locked or located beyond all possibility of movement.

Mass Production, Effect of. The Effect of Mass Production on Machine Tool Design, A. C. Pletz. Am. Mach., vol. 64, no. 22, June 3, 1926, p. 854. (Abstract.) Paper presented before Cincinnati Section, Am. Soc. Mech. Engrs.

Permanent Exhibit. A Permanent Machine Tool Exhibit, J. W. Roe. Am. Mach., vol. 64, no. 23, June 10, 1926, pp. 889–892. Proposed outline for section on machine tools and shop practice of Museum of the Peaceful Arts.

Replacement Policies. Getting the Most Out of Your Machine Tool Dollar, R. A. DeVlieg. Am. Mach., vol. 64, no. 24, June 17, 1926, pp. 929–930. Points out that production guaranties must be met under average conditions rather than under favorable ones; purchaser must make allowances for actual conditions.

Getting the Most Out of Your Machine Tool Dollar, J. E. Gleason. Am. Mach., vol. 64, no. 21, May 27, 1926, pp. 809–811. Seven years is average age of machine equipment in Gleason Works; points considered in replacing; managers are convinced that they can not afford not to buy modern equipment.

MATERIALS HANDLING

Elevator and Conveyor System. Conveyor System. Conveyor System Makes Roof Work, R. A. Fiske. Iron Age, vol. 117, no. 21, May 27, 1926, pp. 1487–1489, 5 figs. Installation of conveyor and elevator system in metal-furniture plant in Kenosha, Wis., which made feasible placing ovens on roofs of 6-story buildings, and also through redesigning of ovens so that drying time was reduced from 4 hours to 1 hour 20 minutes.

Factories. Maker and User Profit by New Methods, E. M. Olin. Mfg. Industries, vol. 11, no. 6, June 1926, pp. 413–416, 6 figs. Handling equipment and straight-line layout cut costs and reduce selling price of Westinghouse Electric Products Co.

Machine Design and. Machine Design and the Handling Problem, F. L. Eidmann. Am. Mach., vol. 64, no. 22, June 3, 1926, pp. 855–856, 5 figs. Heavy machines make difficult handling jobs; designer can provide means of handling castings and moving finished machine; proper and improper base designs.

MEASUREMENTS

Fine. Recent Developments in the Art of Fine Measurement, J. E. Sears. Engineering, vol. 121, no. 3151, June 4, 1926, pp. 652–654, 8 figs. Recent experience shows that it is not possible to get agreement of interpretation between different observers of lines better than 0.00001 in., and this accuracy could be surpassed at present by material end standards with ends finished optically flat and parallel, and by natural standard based upon wave lengths of light; author refers to advance made in this direction; interference methods of measurement; triode valve applied to measurement of small displacements; measurements of internal diameters. (Abstract.) Lecture presented before Roy. Instn.

MECHANISMS

Geneva Movement. Mathematical Analysis of the Geneva Movement, F. Seybold. Am. Mach., vol. 64, no. 20, May 20, 1926, pp. 793–798, 6 figs. Problems of velocity and acceleration conveniently solved by use of tabulated data for three, four, and six-slot Geneva disks.

METALLOGRAPHY

A.S.T.M. Report. Report of Committee E-4 on Metallography. Am. Soc. Testing Matls.—Preprint, for mtg. June 21, 1926, no. 22, 34 pp., 2 figs. Selection and preparation of samples; solutions for carbides, etc., in alloy steels; micro-hardness; bibliography of scratch-hardness methods as applied to metals; glossary of terms relating to radiography; proposed tentative recommended practice for radiographic testing of metal castings, and for care of eyes when using metallographic microscope.

METALS

Cold Deformation. Cold Deformation of Corrosion Fringes (Les franges d'écrouissage ou de corrosion), A. Portevin. Académie des Sciences—Comptes Rendus, vol. 182, no. 8, Feb. 22, 1926, pp. 523–525, 4 figs. Study of effects of chemical reagents on polished surfaces of metals subjected to cold deformation, and in particular of alternate bright and dark striations or "fringes" produced.

Corrosion. Corrosion, Tarnishing and Tinting of Metals, U. R. Evans. Engineering, vol. 121, no. 3151, June 4, 1926, p. 667. Shows that corrosion preferentially attacks those portions to which oxygen has no direct access, and not those exposed to oxygen. Review of two lectures before Roy. Instn.

Flow of Grain. The Influence and Importance of the Flow of the Grain of Metals. Machy. (Lond.), vol. 28, no. 705, Apr. 1, 1926, pp. 9–13, 11 figs. Flow of metal in crankshafts; gear blanks; bushes and tires.

Oxidation. The High Temperature Oxidation of Metals, J. S. Dunn. Roy. Soc.—Proc., vol. 3, no. A757, May 1, 1926, pp. 203–209, 1 fig. Oxidation of three copper-zinc alloys was investigated and shown to be controlled by diffusion through protective film of oxide; rate of oxidation shown to vary exponentially with temperature; theory of diffusion in solid solutions.

Static Strength. Static Permanent Strength of Metals and Alloys (Statische Dauerfestigkeit von Metallen und Legierungen), G. Welter. Zeit. für Metallkunde, vol. 18, nos. 3 and 4, Mar. and Apr. 1926, pp. 75–80 and 117–120, 32 figs. It is shown by means of endurance tests that most metals and alloys are not capable of resisting static superelastic load for prolonged period; as result of investigation, explana-

tion is found for hitherto inexplicable failure of statically stressed structures, such as are observed, for example, in course of time on overhead transmission lines. See translated abstract in Metallurgist (Supp. to Engineer, vol. 141, no. 3670), Apr. 30, 1926, pp 58–60, 4 figs.

X-Ray Examination. Practical Results of Applying X-Rays to Metals (Praktische Ergebnisse der Röntgendurchleuchtung von Metallen), M. Schwarz. Zeit. des Bayerischen Revisions-Vereins, vol. 30, nos. 5 and 6, Mar. 15 and 31, 1926, pp. 49–53 and 65–71, 25 figs. Reviews application of X-rays in locating faults in materials; X-ray apparatus and operation; limits of visibility of cracks and small defects, especially cracks between rivet holes in boiler plate, and in welded seams, cast-iron gears, strained wire, etc.

MILLING CUTTERS

Cost Reduction. Reducing Costs of Cutters and Cutter Grinding, D. A. Hampson. Am. Mach., vol. 64, no. 20, May 20, 1926, p. 784. Use of cutters of single style or make is factor in lowered costs; gives working comparison.

MILLING MACHINES

Milwaukee No. 4. New Milling Machine Has Rapid Traverse for all Motions of Work Table. Automotive Industries, vol. 54, no. 22, June 3, 1926, pp. 940–941, 3 figs. Milwaukee No. 4 line made in plain, universal and vertical types with normal table range of 42 × 14 × 20-in.; designed for electric drive, but provision is also made for belt drive.

Sewing-Machine Parts. Some Unusual Milling Operations on Sewing Machine Parts, H. Densmore. Am. Mach., vol. 64, no. 24, June 17, 1926, pp. 937–940, 9 figs. Universal form-milling machine; performs many operations formerly done by hand; infinite variety of movements possible; uniformity of results assured.

Special. Longitudinal Milling Machine for Railway-Motor Casings (Langfräsmaschine für Bahnmotorgehäuse), M. Coenen. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 18, May 1, 1926, pp. 600–602, 6 figs. Details of special machine with individual drive.

MOLDING METHODS

Car Wheels. Mechanical Molding of Car Wheels, R. F. Ringle. Can. Machy., vol. 35, no. 21, May 27, 1926, pp. 21–22, 5 figs. Methods employed by Brown Car Wheel Works, Buffalo, N. Y.; how obstacles were overcome that previously had curtailed use of molding machines in car-wheel factories.

Grooved Pulleys. The Moulding of Grooved Pulleys, E. Ronceray. Foundry Trade Jl., vol. 33, nos. 510 and 511, May 27 and June 3, 1926, pp. 367–368 and 393–395, 12 figs. First question to be settled is arrangement of various parts; molding with dry cores; using cope; molding in two parts of box without cope or core; molding without cope or core or turning over. June 3: Vertical molding using sectional patterns; stripping by rotation; double-sided pattern plates.

Templet. Templet Molding for a Cast-Iron Cover (Das Aufschablonieren der Form zu einem gusseisernen Deckel), R. Löwer. Werkstattstechnik, vol. 20, no. 8, Apr. 15, 1926, pp. 253–256, 13 figs. Details and drawings showing advantages of templet molding over pattern construction.

MOTOR-BUS TRANSPORTATION

Boston and Maine Railway. B. & M. Buses Improve Rail Service. Ry. Age, vol. 80, no. 25, May 22, 1926, pp. 1395–1399, 5 figs. Boston and Maine has instituted comprehensive plan for improvement of passenger service; train stops eliminated and all schedules quickened; seek to win passengers from their own automobiles.

Great Northern Railway. Great Northern Largest Railway Bus Operator. Ry. Age, vol. 80, no. 25, May 22, 1926, pp. 1401–1404, 4 figs. Approximately 3000 miles of bus lines covered by 140 motor buses; service being coördinated with that of railway.

Inter-City. The Problems of Intercity Motorcoach Operation, A. Shapiro. Soc. Automotive Engrs.—Jl., vol. 18, no. 6, June 1926, pp. 601–603. Discusses appearance and riding qualities that appeal to patrons; size and length of life with relation to frequency of service and replacement; choice of routes with reference to character of roads, etc.: running schedules; lay-over stops for refreshment and relaxation; speed; dependability of service; etc.

MOTOR BUSES

Electric Drive. Review of the Electric Drive Type of Transmission, H. L. Andrews. New York Railroad Club—Official Proc., vol. 36, no. 6, Apr. 16, 1926, pp. 7982–7988, 4 figs. Simplicity, continuous torque, ease of control and durability among various derived advantages.

Gasoline-Electric. Chicago and Alton Begins Gas-Electric Coach Service, L. C. Paul. Railroad Herald, vol. 30, no. 7, June 1926, pp. 20–24, 4 figs. Eight-wheel, double-truck coaches now being placed in service seat 35 passengers and can turn around in practically their own length.

MOTOR TRUCKS

Impact Tests. General Results of the Coöperative Motor-Truck Impact-Tests, J. A. Buchanan and J. W. Reid. Soc. Automotive Engrs.—Jl., vol. 18, no. 6, June 1926, pp. 581–592, 26 figs. Authors state eight preliminary deductions drawn from present available data and discussed mode of static and impact-test accomplishment, and describes accelerometer used; illustrated analysis of highway and obstruction tests.

Inspection. Inspection, A Means for Economical Motor-Truck-Fleet Maintenance, F. E. Hatosy. Soc. Automotive Engrs.—Jl., vol. 18, no. 6, June 1926, pp. 637–638 and (discussion) 638–640. Author enumerates main details of adequate inspection.

Morris. Morris $1^1/_2$-Ton Truck Furnished With Either Four or Six Wheels, M. W. Bourdon. Automotive Industries, vol. 54, no. 22, June 3, 1926, pp. 926–928, 7 figs. British firm also introduces one-man army tank which uses same engine as truck and which is convertible for farm-tractor service with speed of 30 m.p.h.

Relay Drive. The Commerce Relay Drive Truck, L. S. Gillette. Operation & Maintenance, vol. 33, no. 5, May 10, 1926, pp. 36–37, 4 figs. By applying new principle to rotate rear wheels, latest Commerce Relay Drive $3^1/_2$-ton trucks are said to have improved their performance and field of utility by margin of over 100 per cent; weight of truck and its load are employed advantageously to assist in rolling rear wheels, thus gravity is used to help maintain momentum of truck while under way, to assist in starting or overcoming obstacles or holes, and to provide additional traction when truck is in soft ground.

Renault. The Latest Renault One-Tonner. Motor Transport, vol. 42, no. 1106, May 24, 1926, pp. 589–591, 5 figs. Equipped with 13.9-hp. 4-cylinder engine with forced lubrication; conspicuous change in design is seen in new method of rear springing, replacing semi-elliptic side springs of older model.

Saurer. The Latest Sauer Six-Wheeler. Motor Transport (Lond.), vol. 42, no. 1104, Apr. 26, 1926, pp. 515–516, 4 figs. New flexible tractor-trailer unit constructed for loads up to 16 tons.

N

NON-FERROUS METALS

Standard Specifications. Report of Committee B-2 on Non-Ferrous Metals and Alloys. Am. Soc. Testing Matls.—Preprint, no. 18, for mtg. June 21, 1926, 35 pp., 8 figs. Committee reports on pure metals in ingot form, wrought metals and alloys, white metals, methods of chemical analysis; method for determination of aluminum in small quantities; properties of high-strength aluminum casting alloys; proposed tentative specifications for aluminum-bronze castings; sand castings of copper and tin and zinc alloys; steam or valve bronze sand castings; composition-brass or ounce-metal sand castings; aluminum-base sand-casting alloys in ingot form; aluminum sheet.

O

OIL ENGINES

Air Filters. Self-Cleaning Air Filter of Low Resistance. Oil Engine Power, vol. 4, no. 6, June 1926, pp. 354–355, 6 figs. Describes protectomotor marketed by Staynew Filter Corp.; basis of device is filtering cloth of special close texture; examples of applications.

Bagnulo. The Bagnulo Heavy-Oil Engine. Engineering, vol. 121, no. 3152, June 11, 1926, pp. 692–694, 7 figs. partly on supp. plate. These engines have compression pressure of 170 lb. per sq. in., will run at any speed between 250 and 2000 r.p.m., and will tick over at former speed on no load for indefinite periods; engines operate on four-stroke cycle.

Developments. Recent Oil Engine Developments, J. L. Chaloner. Diesel Engine Users Assn.—Report of Discussion, for mtg. Apr. 17, 1925, no. 51, 48 pp., 22 figs. General review of many types of engines available for power purposes, taking as basis recent exhibits at Wembley Exhibition 1924.

Fuel-Distributing Gear. A New Fuel Distributing Gear. Engineer, vol. 141, no. 3674, June 11, 1926, p. 608, 2 figs. New type designed by Ruston-Hornsby; fuel pump delivers fuel oil under pressure to distributor casing from which leads are taken to various cylinders; only one fuel pump is now used for all engines other than 6-cylinder units.

Fuel Pumps. Care, Adjustment, and Maintenance of Oil Engine Fuel Pumps, A. B. Newell. Nat. Engr., vol. 30, no. 5, May 1926, pp. 197–199. Practical discussion on care of fuel pumps, their proper adjustment, and hints on their maintenance; fuel-pump troubles on different types of engines and how to prevent them.

Heavy-Oil. The Campbell Vertical Heavy-Oil Engine. Engineering, vol. 121, no. 3151, June 4, 1926, pp. 656–658, 6 figs. 100-b.hp. engine constructed by Campbell Gas Engine Co., Halifax, and results of demonstration to show suitability of these engines for synchronizing to work in parallel on a network.

McIntosh & Seymour. Test of Big McIntosh & Seymour Engine. Motorship, vol. 11, no. 6, June 1926, pp. 435–443, 16 figs. Record 6-cylinder 2700-s.hp. single-acting 4-cycle set successfully completes official 30-day full power trial for U. S. Shipping Board.

Plenty-Still. The Plenty-Still Oil Engine. Shipbldg. & Shipg. Rec., vol. 27, nos. 20 and 21, May 20 and 27, 1926, pp. 550–552, 3 figs. 130 to 150 b.hp. produced in cylinder of $17^1/_4$-in. bore with moderate mean pressure and piston speed; poppet-type steam valves adopted.

OIL FUEL

Applications. Oil-Burning for General Uses, F. Burgess. Junior Instn. Engrs., vol. 36, Apr. 1926, pp. 300–310, 2 figs. Advantages, economy and disadvantages of oil fuel; oil burners; steam-jet, air-jet, and pressure-jet systems; fuel heater and pumps.

Burners. The Ray Rotary Fuel Oil Burner Test on a Marine Scotch Boiler, R. C. Brierly. Am. Soc. Nav. Engrs.—Jl., vol. 38, no. 2, May 1926, pp. 271–288, 5 figs. Results of tests on burners manufactured by W. S. Ray Co., San Francisco, Cal.; it is made up of atomizer and register, and also embodies in each unit turbo-blower which not only rotates atomizer cup and furnishes atomization, but also helps register in its function of air admission and control.

Railways. Fuel Oil for Railways, J. C. Martin, Jr. Mech. Eng. (Supp.), vol. 48, no. 6, June 1926, pp. 671–672. Points out reasons that economically warrant continuance of its use on railways, even to extent of its allotment for use in locomotive fireboxes for steam-generating purposes should its conservation in future become national issue.

OPEN-HEARTH FURNACES

Comparison of Different Capacities. Comparison of Open-Hearth Furnaces of Various Sizes, S. J. Cort. Am. Iron & Steel Inst.—Advance paper, for mtg. May 21, 1926, 16 pp. Comparison of operations of furnaces of different capacities; author emphasizes that inherently there is no reason why as good steel can not be made in large as in small furnaces. See also abstract in Iron Age, vol. 117, no. 21, May 27, 1926, pp. 1493–1494; and Am. Metal Market, vol. 33, no. 112, June 12, 1926, pp. 6–7 and 18.

OXYACETYLENE CUTTING

Cast Iron. Cutting Cast Iron with the Torch. Welding Engr., vol. 11, no. 5, May 1926, pp. 25–26, 5 figs. Development of special torch which provides for preheating of cutting jet of oxygen. Translated from Revue de la Soudure Autogène.

OXYACETYLENE WELDING

Copper Fireboxes. Welding Copper Fireboxes, H. Young. Welding Engr., vol. 11, no. 5, May 1926, pp. 27–29, 6 figs. Oxyacetylene process used for repair of practically all defects; many welds may be made in place.

Gas-System Regulation. Regulation for the Installation and Operation of Gas Systems for Welding and Cutting. Acetylene Jl., vol. 27, no. 12, June 1926, pp. 596–600. Regulations of National Board of Fire Underwriters as recommended by National Fire Protection Assn.

Sheet Aluminum. Oxy-Acetylene Welding of Sheet Aluminum, J. W. Meadowcroft. Acetylene Jl., vol. 27, no. 12, June 1926, p. 591, 1 fig. Method developed in Philadelphia plant of E. G. Budd Mfg. Co.

P

PEAT

Utilization. Possibilities for the Commercial Utilization of Peat, W. W. Odell and O. P. Hood. U. S. Bur. of Mines—Bul., no. 253, 1926, 154 pp., 32 figs. Composition of peat; classification of peat deposits; distribution of peat in United States; winning of peat fuel; laboratory experiments with Minnesota peat; machined peat fuels; carbonization of peat and recovery of by-products; production of ethyl alcohol from peat; special prepared-peat products; agricultural utilization of peat lands; suggestions for utilizing peat resources of United States.

PIPE

Bending. Pipe Filling and Stamping Plant (Rohrfüll und Klopfwerk), H. Heinze. Werkstattstechnik, vol. 20, no. 8, Apr. 15, 1926, pp. 243–246, 8 figs. Discusses conditions to be filled by plant for filling pipe with sand and stamping sand to prevent denting of pipe in bending.

PISTONS

Flow of Heat in. Flow of Heat in Pistons, H. A. Huebotter and G. A. Young. Purdue Univ.—Bul., vol. 9, no. 12, Dec. 1925, pp. 5–114, 67 figs. Shows how satisfactory distribution of metal in plain pistons is obtained; suggestions regarding ribs, piston rings, ring-land radial clearance, and methods of expansion control; principles of piston design are developed by mathematical analysis of heat flow from hot gas through piston and into cylinder wall; analytical study is supplemented by laboratory tests.

PLATES

Corrugated. The Elastic Stability of a Corrugated Plate, W. R. Dean. Roy. Soc.—Proc., vol. 3, no. A757, May 1, 1926, pp. 144–167, 5 figs. Deals with elastic stability of corrugated plate under thrust along its generators.

Mild-Steel. Lives of Maximum Principal Stress in Thin Mild Steel Plates of Rectangular Shape Fixed Along the Edges and Uniformly Loaded, B. C. Laws and A. O. Allen. Lond., Edinburgh & Dublin Philosophical Mag. & Jl. Sci., vol. 1, no. 5, May 1926, pp. 1039–1042, 1 fig. It was sought to determine in what manner stress varies from point to point and how plate changes in form under load; microscopic observations of deflexions were made at points of intersection of ordinates drawn on plate surface parallel to sides of rectangle and represented graphically.

POWER

Growth and Distribution, United States. Growth and Distribution of Primary Power, S. B. Ladd. Power, vol. 63, no. 24, June 15, 1926, pp. 328–330, 5 figs. Presents charts based on reports of Bureau of Census, showing growth of primary power installations of United States.

Water and Steam, California. Water Power and Steam Power in California Utilities, H. A. Barre. Mech. Eng. (Supp.), vol. 48, no. 6, June 1926, p. 662. Brief analysis of power situation to determine respec-

tive contributions of water power and steam power to existing conditions, and their probable future effects.

PRESSES

Plastic Materials. Presses for Plastic Materials and Hot Pressing. Machy. (Lond.), vol. 28, no. 705, Apr. 1, 1926, pp. 6–7, 5 figs. Press exhibited at British Industries Fair in Birmingham, made by Taylor & Challen, for plastic materials and for hot-pressing brass.

PRESSURE VESSELS

Welded. Are Welded Pressure Vessels Safe? E. E. Thum. Power, vol. 63, no. 23, June 8, 1926, pp. 886–889, 7 figs. Outlines procedure control and inspection that should result in safe and satisfactory welds; fundamental principles of oxwelded design; material for welding rod.

PULVERIZED COAL

Boiler Firing. Pulverized Fuel at Dover Power Station, E. K. Scott. Combustion, vol. 14, no. 5, May, 1926, pp. 320–321, 2 figs. Test figures obtained at Dover Corp. with recently developed system of firing pulverized coal.

Use of Pulverized Coal for Boiler Firing (L'emploi du charbon pulverisé), M. Orengo. Société des Ingenieurs Civils de France—Procès Verbal, no. 7, Apr. 16, 1926, pp. 143–148. Types of pulverizers, combustion and design of furnaces; ash handling advantages and future development.

Explosion Hazards. Explosion Hazards From the Use of Pulverized Coal at Industrial Plants, L. D. Tracy. U. S. Bur. Mines—Bul., no. 242, 1925, 99 pp., 36 figs. Presents both bad and good features of pulverized-coal plants and gives recommendations for safe installation and operation; opinion based largely on results of tests at experimental mine and in laboratory dust gallery.

PUMPING ENGINES

Triple-Expansion. The Chelvey Pumping Station of the Bristol Waterworks Company. Engineering, vol. 121, no. 3151, June 4, 1926, pp. 659–661, 4 figs. partly on p. 664. Extension of existing pumping plant by addition of triple-expansion engine driving deep-well and surface pumps, together with 3 Lancashire boilers, superheaters, economizers and usual auxiliaries; engine is inverted vertical type, with cylinders carried on cast-iron standards behind and polished steel columns in front.

PUMPING STATIONS

Chicago. Selecting Equipment for Western Avenue Pumping Station, L. D. Gayton. Power, vol. 63, no. 22, June 1, 1926, pp. 840–844, 3 figs. Summary of comparative studies made in selecting pumping units, number and size of boilers, fuel-burning equipment and evaporators over softeners for makeup; steam turbine-geared centrifugal pumps showed lowest overall operating economy, and underfeed stokers were selected in preference to pulverized coal or oil.

Power Generation. Generating Power for the Pumping Plant, Prof. E. A. Allcut. Power House, vol. 19, no. 11, June 5, 1926, pp. 46–48. Reviews present practice and future developments. Paper read before Can. Section, Am. Water Works Assn.

PUMPS

Power-Drive Equipment. Power Drive Equipment for Industrial Pumps, G. Fox. Indus. Engr., vol. 84, no. 5, May 1926, pp. 208–212, 8 figs. Discussion of operating characteristics of pumps which affect selection of motor control and drive connection.

PUMPS, CENTRIFUGAL

Automatic Primers. Automatic Primers for Centrifugal Pumps, F. H. Bradford. Am. Water Wks. Assn.—Jl., vol. 15, no. 6, June 1926, pp. 647–649, A. P. C. O. automatic primer for centrifugal pumps consists of tank divided by partition in middle into two parts, one above the other, arranged for connections to pump; lower half is connected to suction and upper half to discharge side of pump; its purpose is to automatically prime valveless pump without use of foot valve or any other mechanical contrivance which might be subject to wear and tear.

Characteristics. Centrifugal Pumps, M. D. Engle. Elec. Light & Power, vol. 4, no. 4, Apr. 1926, pp. 21–23 and 86, 6 figs. Discusses characteristics from standpoint of purchaser and points out most desirable form of characteristic for various services for which centrifugal pumps are used in power stations; consideration on drive for different pumps.

Hot-Water. Pumping Water Near the Boiling Point (Heisswasserförderung durch Turbokesselspeisepumpen), M. Knörlein. Wärme, vol. 49, no. 13, Mar. 26, 1926, pp. 219–222, 9 figs. In modern power plants it is frequently necessary to pump water which is within few degrees of boiling point, and it is important to avoid local reductions in pressure; author shows that centrifugal pumps can be relied upon to deal with water within few degrees of boiling point under pressure concerned, provided that intake pipe be large and suction inlet to first stage of pump be large and free from sharp bends; typical performance curves for turbo-pumps handling hot water under different conditions, and general arrangement of pump-testing plant.

Theory. The Theory of Centrifugal Pump in Practical Form and its Extension on the Other Machines, K. Okamoto. Soc. Mech. Engrs. (Japan)—Jl., vol. 29, no. 108, Apr. 1926, pp. 173–234, 40 figs. Presents improved formulas for manometric head and impelling horsepower of centrifugal pumps having specially formed impellers which may be applied widely in practice.

PYROMETERS

Aspiration. High-Temperature Measurements. Engineering, vol. 121, no. 3150, May 28, 1926, p. 626, 3 figs. Aspiration pyrometer developed by Wärmestelle Düsseldorf, Germany, in order to obtain more reliable measurements of actual gas temperature, without couples to contamination by gases, soot and dust; consists of sheathed thermocouple, mounted in tube through which gas, temperature of which is to be determined, is drawn at measureable rate.

RAILS

Corrugation. Resistance to Wear and Rail Corrugation (Verschleisswiderstand und Riffelbildung), Kayser. Verkehrstechnik, vol. 39, no. 15, Apr. 9, 1926, pp. 240–241, 1 fig. Reviews experiments carried out to clear up question of corrugation, and describes recent tests which seem to show that corrugation is connected with degree of slip.

R

RAILWAY ELECTRIFICATION

Chicago Suburban Service. Electrification of the Illinois Central Railroad Suburban Service in Chicago, W. M. Vanderluis. West. Soc. Engrs.—Jl., vol. 31, no. 3, Mar. 1926, pp. 75–93 and (discussion) 93–96, 10 figs. Details of new electrified service to be opened to public in July 1926; power is to be purchased under new form of service contract requiring sellers to build and operate 7 sub-stations which will contain first large installation of mercury-arc rectifiers to be used in United States; trains will consist of 2-car motor and trailer units semi-permanently connected and will attain speeds of 57 miles per hour.

Italy. Electric Railway Rome-Ostia (La ferrovia elettrica Roma-Ostia), A. Banti. Elettricista, vol. 35, no. 2, Jan. 15, 1926, pp. 17–21, 7 figs. Details of line from Rome to sea, about 59 km.; d.c. traction at 2400 volt; power furnished by Rome municipal plant, 3-phase at 30,000 volts, 46 cycles; sub-stations, rolling stock, etc.; operating speed, 60 km. per hr.

Switzerland. Railway Electrification in Switzerland. Ry. Gaz., vol. 44, nos. 21 and 22, May 21 and 28, 1926, pp. 691–692. Particulars compiled by British Legation at Berne and issued through Department of Overseas Trade.

RAILWAY MOTOR CARS

Developments. Rail Motor Cars and Internal-Combustion Locomotives (Les automotrices et locomotives à combustion interne), A. Bourgain. Nature (Paris), nos. 2712, Mar. 27 and Apr. 3, 1926, pp. 200–205 and 217–221, 16 figs. Development of traction on rails by means of internal-combustion engines; design of Schneider and Moyse loco-tractors; development of various types of transmission gears by Fieux, Hele-Shaw, Collardeau; various types of railway motor cars.

Gasoline-Electric. Gas Electric Coaches Built for C. & A., L. C. Paul. Ry. Rev., vol. 78, no. 22, May 29, 1926, pp. 943–946, 6 figs. Eight-wheel, double-truck coaches seat 35 passengers and can turn around in their own length.

Passenger and Baggage. Unique Cooling System Incorporated in New Rail Car Design. Automotive Industries, vol. 54, no. 21, May 27, 1926, pp. 880–882, 5 figs. Radiator placed in roof of combination passenger and baggage car built by Minneapolis Steel & Machinery Co.; six-cylinder 175-hp. engine is used with positive drive on all four axles.

RAILWAY REPAIR SHOPS

Car Repairs. Wabash Builds Steel Car Shop at Decatur. Ry. & Mech. Engr., vol. 100, no. 6, June 1926, pp. 340–344, 8 figs. Modern plant with track space for 66 cars and potential output of 15 cars a day.

Freight Cars. Wabash Builds New Freight Car Repair Shops. Ry. Rev., vol. 78, no. 23, June 5, 1926, pp. 1009–1011, 5 figs. Large fireproof structure fitted with modern equipment added to other new facilities at Decatur, Ill.

Locomotive. A. T. & S. F. San Bernardino Locomotive Shops. Ry. Mech. Engr., vol. 100, no. 6, June 1926, pp. 362–370, 15 figs. Stripping pits and 21 pits for heavy boiler and tender work in boiler shop; 30 pits in erecting shop.

In the "Katy Shops," F. W. Curtis. Am. Mach., vol. 64, no. 20, May 20, 1926, pp. 771–774, 11 figs. Methods and equipment; operations worked out at Parsons, Kan., shops of Missouri-Kansas-Texas Railroad Co. for handling miscellaneous work.

The Macon Shops of the Central of Georgia. Ry. Elec. Engr., vol. 17, no. 6, June 1926, pp. 183–187, 10 figs. Shop is completely electrified; detail of power distribution; equipment; maintaining electrical equipment and coil construction; new filter plant.

Welding and Air Equipment. Welding and Air Equipment in the Danville Shops, R. W. Curtis. Am. Mach., vol. 64, no. 24, June 17, 1926, pp. 941–943, 9 figs. Welding of locomotive units; both electric and oxyacetylene equipment used; labor-saving tools operated by air; home-made press for brasses.

RAILWAY SHOPS

Scrap Handling in. Lackawanna Reduces Scrap Handling Costs 72 Per Cent. Ry. Age, vol. 80, no. 27, June 5, 1926, pp. 1471–1473, 6 figs. New facilities at Scranton, Pa., retire 6 old plants and release 29 men from force.

Tool Rooms. System Tool Room on C. M. & St. P., O. D. Kinsey. Ry. Mech. Engr., vol. 100, no. 6, June 1926, pp. 359–361, 8 figs. How Chicago, Milwaukee & St. Paul standardized tool equipment and centralized tool facilities at one of these shops.

RAILWAY SIGNALING

Color-Light Signals. Colour-Light Signalling on the Southern Railway. Ry. Engr., vol. 47, no. 556, May 1926, pp. 170–174 and 182, 3 figs. Account of theoretical considerations underlying four-aspect system, its practical application between Holborn Viaduct and Elephant and Castle, which constitutes first installation of its kind in world.

Extensive Grade Crossing Protection Installed on Pennsylvania, D. J. Millison. Ry. Signaling, vol. 19, no. 6, June 1926, pp. 229–231, 6 figs. Total of 31 flashing-light signals at 13 crossings, controlled with a.c. track circuits, replace 10 flagmen formerly employed 12 hours a day.

Scientific Study of Light Signals, D. J. McCarthy. Ry. Signaling, vol. 19, no. 6, June 1926, pp. 224–228, 4 figs. Fundamentals of physics and physiology as applied to modern color-light signals used in railway service.

Power Lines. New York Central Completes New Signal Power Line, R. B. Elsworth. Ry. Signaling, vol. 19, no. 6, June 1926, pp. 217–220, 5 figs. Transmission voltage of 4600 employed to supply ample power for signal and train-control systems as well as other roadway facilities.

RAILWAY SWITCHES

Automatic. Automatic Electric Switches for Street Car or Railway Lines, Hervé System (Dispositif d'aiguillage automatique électrique pour tramways ou chemins de fer Système breveté Hervé), M. Weiler. Industrie des Voies Ferrées et des Transports Automobiles, vol. 20, no. 230, Feb. 1926, pp. 110–113, 3 figs. Design and operation of switch controlled from platform of electric car, action being entirely mechanical, reducing short circuits to minimum.

REFRIGERATING MACHINES

Corblin. The Corblin Refrigerating Machine (La Machine Frigorifique "Corblin"), A. Troller. Nature (Paris), no. 2715, Apr. 17, 1926, pp. 244–247, 7 figs. Design and operation of machine with steel membrane compressor in place of piston compressor, eliminating stuffing box and lubrication.

Magnet Mechanical. The Magnet Mechanical Refrigerator. Engineering, vol. 121, no. 3151, June 4, 1926, p. 674, 2 figs. Machine constructed by Gen. Elec. Co., London, which can be operated with perfect safety by entirely unskilled person.

REFRIGERATION

Electric. Present and Future of Domestic Electric Refrigeration, H. G. Scott. Refrig. Eng., vol. 12, no. 10, Apr. 1926, pp. 338–339. Review of developments and work of Society for Electrical Development.

ROLLING MILLS

Cold Strip Rolling. The Cold Rolling of Strip Steel, C. B. Huston. Gen. Elec. Rev., vol. 29, no. 6, June 1926, pp. 386–393, 12 figs. Purpose of cold rolling; coiling and pickling; general design of mill; operation and control; tandem and other combinations; magnentic time control.

Drives. Influence of Drive on Efficiency of Rolling Mills (Einfluss der Antriebart auf die Leistung von Blockstrassen), H. Wendt. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 18, May 1, 1925, pp. 585–592, 15 figs. Points out difficulty of obtaining reliable data when comparison is attempted between steam and electrically driven roll, operated by different crews; author attempts to eliminate human element by constructing from large number of individual rolling diagram records best average diagram representing rolling process of given ingot into certain final shape; method followed for steam operation and for electric drive with Ilgner converter set; large number of records are reproduced as curves and tabulations, showing distinct advantages for electric drive.

Spread in Rolling. "Spread" of Metal in Rolling, C. E. Davies. Engineer, vol. 141, nos. 3674 and 3675, June 11 and 18, 1926, pp. 598–600 and 626–627, 17 figs. Determination of spread in cold rolling round, square and comparatively narrow rectangular sections; ratios are given connecting per cent spread and per cent reduction; concludes tnat nature and conditions of metal rolled appear to have surprisingly little influence on spread; diameter of rolls used in effecting reduction does make some, though small, difference in spreading; spread is definitely proved to increase with reduction in thickness effected, and this factor is by far the greater influence; difference of spread obtained with same reductions on various sections has been clearly shown.

Wire-Rod. Wire Rod Mills, J. D. Wright. Gen. Elec. Rev., vol. 29, no. 6, June 1926, pp. 380–386, 13 figs. Rod-rolling industry; development and methods in wire-rod rolling; Garrett and continuous mills; analysis of rod-mill load; steps in rod rolling in modern mill; electrification of these mills.

S

SCALES

Types and Uses. Scales Speed Up Mass Production, F. L. Prentiss. Iron Age, vol. 117, no. 23, June 10, 1926, pp. 1635–1638, 7 figs. Monorail scale for weighing raw material; how counting scale is used; sorting parts with scale; testing springs for resistance; electric recording apparatus for conveyor scale.

SCREW MACHINES

Cost Estimating. Screw Machine Cost Estimating, J. M. Hemphill. Machy. (N. Y.), vol. 32, no. 11, July 1926, pp. 868–869, 2 figs. Items upon which costs of automatic screw-machine products are based, and use of cost-estimating data sheets.

SEMI-DIESEL ENGINES

High-Speed. The Fundamental Principles of High-

Speed Semi-Deisel Engines, Büchner. Nat. Advisory Committee for Aeronautics—Tech. Memorandums, no. 358, Apr. 1926, 26 pp., 13 figs. Discussion of fuel mixing and ignition, with special reference to engines with precombustion chambers. Translated from Jahrbuch der Brennkrafttechnischen Gesellschaft, vol. 5, 1924.

SEPARATORS

Ash-Reclamation. Future of Magnetic Separation of Ash Residues (Die Zukunftsbedeutung der magnetischen Aufbereitung der Feuerungsrückstände), Wintermeyer. Brennstoff- u. Wärmewirtschaft, vol. 8, no. 7, Apr. 1, 1926, pp. 110–112, 1 fig. Ullrich-Krupp system of magnetic separation for grain sizes of 5 to 25 mm., and its advantages over wet separation.

SHEARS

Plate. Bergue Multiple Shears for Sheet Rolling Mills (Cisaille multiple, système De Bergue), Génie Civil, vol. 88, no. 15, Apr. 10, 1926, pp. 329–332, 5 figs. De Bergue electrically driven metal-cutting machine used for cutting a number of sections with one operation and with minimum of manual work.

SHEET METAL

Tensile Properties. Effects of Size and Shape of Test Specimen on the Tensile Properties of Sheet Metals, R. L. Templin. Am. Soc. Testing Matls.—Preprint, no. 37, for mtg. June 21, 1926, 21 pp., 13 figs. Investigation covering extensive series of tension tests on three types of sheet metals, namely; (1) material having comparatively high tensile strength and low elongation, (2) material having comparatively low tensile strength and high elongation; (3) material having both high tensile strength and high elongation; results indicate quite definitely that tensile strength and yield point of material are affected in only few extreme cases by size and shape of test specimen used; elongation is affected quite seriously by total cross-sectional area rather than by form of test specimen.

SMOKE

Abatement. How Cities Can Control the Smoke Nuisance, H. B. Meller. Nat. Mun. Rev., vol. 15, no. 5, May 1926, pp. 270–276. Experiences in Pittsburgh in solving smoke problem; author states that smoke emission, regulated by law, has decreased 80 per cent within last fifteen years.

STANDARDS

German N.D.I. Reports. Report of German Industrial Standards Committee (NDI-Mitteilungen), W. Reichardt. Maschinenbau, vol. 5, no. 8, Apr. 15, 1926, pp. 385–388. Proposed standards for grooved spring steel, rolled; and for elliptic springs for locomotives, automobiles, trucks, etc.

Reports of German Standards Committee (NDI-Mitteilungen), W. Reichardt. Maschinenbau, vol. 5, no. 9, May 6, 1926, pp. 429–440. Proposed standards for wrenches for square nuts; letter cards and post cards; ordinary wire nails with various types of heads and without head; staples; nickel and chrome steels for automobile construction.

Jigs and Fixtures. Standardizing Jigs and Fixtures (Normung der Vorrichtungen und Vorrichtungs-Spannungen), P. Grodzinski. Maschinenbau, vol. 5, no. 9, May 6, 1926, pp. 396–401, 2 figs. Discusses problems of standardization and NDI standards already in existence.

Taper Keys. Tentative Standards for Stock Taper Keys. Am. Mach., vol. 64, no. 21, May 27, 1926, p. 816, 2 figs. Tentative standards for plain and gib-head stock taper keys have been prepared by Subcommittee on Standardization of Shafting of Am. Soc. Mech. Engrs.

STEAM

High-Pressure. Advantages and Disadvantages of High Steam Pressure in Industrial Plants, J. Pope. Stone & Webster Jl., vol. 38, no. 5, May 1926, pp. 622–642, 7 figs. For purpose of discussion high-steam pressure is considered to be any pressure in excess of 200 lb. per sq. in.; theoretical and practical considerations; relative cost of equipment for various steam pressures; examples of use of high-pressure steam.

Superheating. Proposed Method for the Automatic Superheating of Steam. Engineer, vol. 141, no. 3671, May 21, 1926, p. 516. Discusses way by which steam may be automatically raised in temperature without use of any running machinery whatever; principle is reverse of that employed in ordinary refrigerating cycle.

STEAM ENGINES

Back-Pressure, Regulation of. Regulation of Sulzer Back-Pressure Steam Engines (Regelung von Gegendruck-Dampfmaschinen, Bauart Sulzer), A. Ostertag. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 21, May 22, 1926, pp. 705–710, 18 figs. Modern types of governors for economic utilization of exhaust steam of back-pressure engines; automatic pressure-reducing and live-steam by-pass valves in combination with Sulzer pressure regulators; examples of application.

Uniflow. First and Largest Uniflow Engine on Blooming Mill. Power, vol. 63, no. 25, June 22, 1926, pp. 968–972, 8 figs. Four-cylinder condensing uniflow engines—one on continuous mill that at 45 per cent, will develop 14,000 i.hp., and reversing engine having maximum rating of 30,000 i.hp.; capacity is 100 tons of steel per hour, at steam consumption of 280 lb. per ton of steel for reversing engine.

STEAM POWER PLANTS

Design. Steam Power in Generating Stations (Die Dampfkraft im Elektrizitätswerk), P. Scholtes. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 21, May 22, 1926, pp. 685–691, 4 figs. Differences in electricity supply of various countries; based on load curve, heavy fluctuations in power output and in boiler plant are discussed; boiler design and influence of marine-boiler design; steam turbines and boiler furnaces; steam pressure and temperature; feedwater treatment; economy of steam plants; prospects of future development.

Electric Auxiliaries. Electrically-Driven Steam Power Plant Auxiliaries, J. W. Dodge. Gen. Elec. Rev., vol. 29, nos. 5 and 6, May and June 1926, pp. 340–346 and 427–439, 25 figs. May: Standardizing methods of driving auxiliaries; classification of equipment; power supply from different sources; relays; motors and control. June: Motors for various pump drives; generator-ventilating fans; draft-fan drives; stokers and coal feeders; coal-handling equipment.

High-Pressure. Investigations of the 60-Atmos. Steam Plant at the Works of A. Borsig, Berlin-Tegel (Untersuchungen an der 60 atp Dampfkraftanlage von A. Borsig), E. Josse. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 21, May 22, 1926, pp. 677–684, 11 figs. Description of plant; boiler test showed 82.9 per cent efficiency with minimum and 79.3 per cent efficiency with maximum calorific value; investigation of back-pressure steam engine, showing efficiency at 844 hp. with 57.8 atmos. absolute initial pressure, 400-deg. cent. initial steam temperature, 12-atmos. absolute back pressure and 211 deg. steam temperature back of low-pressure cylinder; a thermodynamic efficiency of 91 per cent for the whole engine, and 92.7 per cent for high-pressure cylinder alone, was obtained.

Why Higher Pressures are Advantageous for Industrial Plants, W. Slader. Power, vol. 63, no. 23, June 8, 1926, pp. 883–885. Higher initial pressure makes possible increased extraction pressures and opens way for use of bled steam for even high-temperature process work.

Hydraucone Application to. How to Fight Low Water in a Condensing Plant, J. R. James. Power, vol. 63, no. 24, June 15, 1926, pp. 930–931, 2 figs. Falling water level in Great Lakes is serious problem for plants in that region; solution described is interesting adaptation of hydraulic-turbine practice to steam plant.

Increased Coal Prices, Effect of. The Effect of Increased Coal Prices on the Private Power Plant, E. Douglas. Nat. Engr., vol. 30, no. 6, June 1926, pp. 237–239. Cost of purchased current in future will be based on market value of coal; sidelight on current rates from hydroelectric systems; comparison of power costs of private plants and public-utility service.

Industrial Plants. Selecting a Power and Heat Supply for Industrial Plants, M. K. Bryan. Mech. Eng., vol. 48, no. 6, June 1926, pp. 567–571, 8 figs. Basis on which schemes used to supply heat and power to industrial plants may be compared; curves illustrating power and steam demands of different industries.

STEAM TURBINES

Auxiliary Pumps for. Auxiliary Pumps for 30,000-kw. Steam Turbine. Engineer, vol. 141, no. 3673, June 4, 1926, p. 590, 3 figs. Exhibited by Sulzer Bros., Ludwigshafen, at Leipzig Fair; for use in connection with 3-cylinder steam turbine of 30,000 kw.; circulating water pump, air ejector pump and condensate pump are all mounted on single shaft, which is arranged for direct coupling to 600-hp. 3-phase Brown-Boveri motor running at 960 r.p.m.

Extraction. Utilization of Extraction Steam, South. Power Jl., vol. 44, no. 5, May 1926, pp. 50–55. Part I, by E. D. Dickinson, discusses types and operation of extraction turbines. Part II, by A. D. Somes, discusses ways in which various types of steam turbines may be applied to economical production of power and process steam for industrial purposes. Part III, by R. G. Standerwick, deals with methods of regulating flow of steam through turbines with particular reference to extraction and mixed-pressure applications.

High-Pressure. Steam Turbines for High Pressure (Dampfturbinen für hohen Druck), W. G. Noack. Zeit. des Vereines deutscher Ingenieure, vol. 70, no. 21, May 22, 1926, pp. 711–717, 24 figs. New Types by Brown, Boveri & Co., especially for high pressure; first European maximum-pressure turbine installation in Langerbrugge, Belgium; high-efficiency turbines.

Large. Some Problems in Connection with the Design of Large Turbines, W. B. Flanders. Elec. Jl., vol. 23, no. 5, May 1926, pp. 213–221, 7 figs. Points out that desire for highest efficiency must not be allowed to overshadow practical needs of operator on one hand nor financial balance of investment on the other; discusses types of design.

Mixed-Pressure. Mixed Pressure Turbine Saves $6,000 a Year, W. Arnold. Power, vol. 63, no. 21, May 25, 1926, pp. 810–811, 2 figs. At plant of Pearson & Ludascher Lumber Co., Philadelphia, power formerly purchased is now generated from exhaust steam heretofore blown to atmosphere.

STEEL

Abrasion. Abrasion of Carbon Steels. Soc. Mech. Engrs. (Japan)—Jl., vol. 29, no. 109, May 1926, pp. 273–298, 21 figs. Study of relative abrasion of various carbon steels at state of sliding frictional condition per unit work, coefficient of friction being kept constantly; test was carried out by means of abrasion-testing machine designed by author; specimens were taken from Swedish steels in form of hollow concentric cylinder. (In Japanese.)

Alloy. See ALLOY STEEL.

Corrosion. The Resistance to Corrosion of Copper-Bearing Converter and Open-Hearth Steels (Die Korrosionsbeständigkeit gekupferter Thomas- und Siemens-Martin-Stähle), K. Daeves. Stahl u. Eisen, vol. 46, no. 18, May 6, 1926, pp. 609–611, 4 figs. American and German tests; evaluation of tests by Bauer; comparison of open-hearth and Thomas steels; copper content of 25 per cent greatly increases corrosion resistance to atmospheric attack, and in lesser degree to soil attack.

Deformation. Initial Permanent Deformation in Soft Steel (Les premières deformations permanentes dans les aciers doux), J. Seigle. Génie Civil, vol. 88, nos. 14, 15 and 16, Apr. 3, 10 and 17, 1926, pp. 315–317, 332–336 and 357–358, 45 figs. Discusses appearance of Piobert lines when elastic limit is exceeded in tensile strength test of bars, etc.; Fry reagent which colors those zones of permanent deformation, lines or zones of initial deformation; examples of tension and bending, and of compression.

Fatigue. The Fatigue of Steel and Its Recovery, Y. Fujii. Kyoto Imperial Univ., College of Eng.—Memoirs, vol. 4, no. 2, Mar. 1926, pp. 37–62, 47 figs. Investigation of fatigue followed by physical and chemical phenomena, recovery condition of fatigued steels and nature of fatigue.

Hardness at High Temperature. The Hardness of Carbon Steels at High Temperatures, I. G. Slater and T. H. Turner. Iron & Steel Inst.—Advance Paper, no. 14, for mtg. May 1926, 9 pp., 4 figs. From experimental results, authors conclude that, if riveting takes place between 800 to 1200 deg. cent., the higher the carbon content, up to eutectoid composition, the harder the steels will be to drive; curves indicate that, if danger of burning can be avoided, there is distinct advantage to be gained by using higher temperatures; in process of riveting by hammering a cooling rivet it is clear that, with hammer blows of equal force, first impact will produce more of desired shaping than will any one of subsequent blows. Also abstract in Iron & Coal Trades Rev., vol. 112, no. 3039, May 28, 1926, pp. 842–843, 4 figs.

High-Speed. See STEEL, HIGH-SPEED.

Ingots, Heterogeneity of. The Heterogeneity of Steel Ingots. Engineering, vol. 121, nos. 3149 and 3150, May 21 and 28, 1926, pp. 610–612 and 645–646. Deals with observed facts and theoretical aspects of present problems involved. Report of Sub-committee before Iron & Steel Inst. See also Engineer, vol. 141, no. 3671, May 21, 1926, pp. 528–530.

Ingots, Silicate Distribution in. A Note on the Distribution of Silicates in Steel Ingots, J. H. S. Dickenson. Iron & Steel Inst. Advance Paper, no. 6, for mtg. May 1926, 20 pp., 18 figs. Method used for estimation of non-metallic impurities; distribution of silicates in two typical ingots and in large ingots; microscopic appearance of separated silicates. See also abstract in Engineering, vol. 121, no. 3150, May 28, 1926, pp. 640–641, 4 figs.; and in Iron & Coal Trades Rev., vol. 112, no. 3039, May 28, 1926, pp. 828–831, 14 figs.

Standards. Report of Committee A-1 on Steel. Am. Soc. Testing Matls.—Preprint no. 9, for mtg. June 21, 1926, 59 pp., 3 figs. Recommendations affecting standards and tentative standards; proposed revisions in standards for steel; proposed tentative specifications for open-hearth carbon-steel rails; for manufacture of open-hearth steel girder rails; soft-steel track spikes; steel tie plates; marine-boiler steel plates; hot-rolled bar steels; cold-finished bar steels and shafting; cold-rolled strip steel; pipe flanges for high-temperature service, etc.

Structure. On Ghost Lines and the Banded Structure of Rolled and Forged Mild Steels, J. H. Whiteley. Iron & Steel Inst.—Advance Paper, no. 15, for mtg. May 1926, 6 pp., 8 figs. It is shown that only when variations in percentage of phosphorus between two adjacent areas in iron exceed 0.07 per cent, do they cause removal of carbon, between Ar3 and Ar1, from richer area; evidence is given showing that in certain cases carbon may actually move from one region to another of higher phosphorus concentration; it is shown that ghost lines cannot adequately be accounted for by theory that they are due to crystallization of ferrite on non-metallic inclusions. See also abstract in Engineering, vol. 121, no. 3149, May 21, 1926, pp. 613–614, 4 figs.; also Iron & Coal Trades Rev., vol. 112, no. 3039, May 28, 1926, pp. 832–833, 8 figs.

Tensile Strength and Hardness. The Ratio of the Tensile Strength of Steel to the Brinell Hardness Number, R. H. Greaves and J. A. Jones. Iron & Steel Inst.—Advance Paper, no. 7, for mtg. May 1926, 18 pp., 3 figs. Ratio of tensile strength to Brinell hardness number is dependent on hardness of material and on its yield ratio; for given class of steel ratio decreases with increase of yield ratio and also decreases with increase of hardness up to 375 to 450, depending on composition of steel; summary of ratio of tensile strength to Brinell hardness number, calculated from data obtained in Research Department, Woolwich, and from sources indicated. Bibliography. Also abstract in Iron & Coal Trades Rev., vol. 112, no. 3039, May 28, 1926, pp. 847–848; and Engineering, vol. 121, no. 3151, June 4, 1926, pp. 673–674, 2 figs.

STEEL CASTINGS

Electric Heat Treating. Electric Heat-Treating of Steel Castings, L. E. Everett. Elec. World, vol. 87, no. 23, June 3, 1926, pp. 1233–1236, 4 figs. Practical advantages of electric furnaces in annealing field; utilization of electric energy as source of heat compared with fuel-fired furnaces; method of application.

STEEL, HIGH-SPEED

Hardening and Tempering. The Hardening and Tempering of High-Speed Steel, A. R. Page. Iron & Steel Inst.—Advance Paper, no. 11, for mtg. May 1926, 24 pp., 40 figs. Preliminary investigations on effect of hardening and tempering on microstructure, etc., of two steels; effect of time and temperature of hardening and tempering on hardness of these same steels. See also Engineering, vol. 121, no. 3153, June 18, 1926, pp. 738–739; and abstract in Iron & Coal Trades Rev., vol. 112, no. 3039, May 28, 1926, pp. 833–836, 33 figs.

STEEL WORKS

Germany. The Höntrop Steel of Works the Bochumer Verein (Das Werk Höntrop des Bochumer Vereins), E. Kerl, A. Drieschner and W. Bertram. Stahl u. Eisen, vol. 46, nos. 13 and 14, Mar. 31 and Apr. 8,

1926, pp. 429–436 and 468–475, 22 figs. partly on supp. plate. Details of new plant; open-hearth furnaces, charging and heating equipment; tube rolling mills; Perrins process with inclined rolls; drive and adjustment; flange and thread pipe; power sources and distribution; gas supply; protection against subpressure and superpressure.

Operation. Problems of Steel Mill Operation, A. J. Whitcomb. Indus. Engr., vol. 84, no. 6, June 1926, pp. 249–259, 14 figs. Trends that are being followed in solving problems involving use of electrical and mechanical power-drive equipment; present tendencies in conversion, distribution, and application of electrical energy in iron and steel industry.

Strip Mills. Increases Stripmaking Capacity, E. C. Barringer. Iron Trade Rev., vol. 79, no. 2, July 8, 1926, pp. 71–75, 6 figs. Description of installation in which semifinished material is reheated in furnaces of recuperative type; hot mill train is designed for maximum delivery of 1600 ft. per min.

STOKERS

Lubrication. Lubrication of the Mechanical Stoker, A. F. Brewer. Power, vol. 63, no. 23, June 8, 1926, pp. 895–896. Deals with oiling of worm and spur gearing used for speed-reduction purposes; bearings of electric motors, turbines, steam engines and of such shafting as is involved in operation of movable grates; and steam cylinders where steam engines are used as driving units.

T

TEMPERATURE MEASUREMENTS

Instruments. The Science of Temperature Measurement, H. M. Brown. Indus. Chemist, vol. 2, no. 15, Apr. 1926, pp. 166–168, 7 figs. Deals with four types of temperature-measuring instruments, namely, mercurial thermometer, electrical resistance thermometer, electrical thermocouple instrument and optical pyrometer.

TERMINALS, LOCOMOTIVE

Battle Creek, Mich. Grand Trunk Builds New Engine Terminal. Ry. Rev., vol. 78, no. 23, June 5, 1926, pp. 985–992, 15 figs. Modern facilities at Nichols, near Battle Creek, Mich.; house is served by 90-ft. turntable of three-point continuous type; heating of enginehouse is by indirect system; details of power plant, piping and boiler-washing system; office and stores buildings; grading and track work.

TESTS AND TESTING

Materials. Some Practical Aspects of the Testing of Materials, M. Moser. Metallurgist (Supp. to Engineer, vol. 141, no. 3672), May 28, 1926, pp. 79–80. Deals with tensile, hardness and bend testing; author emphasizes necessity for exercising discretion in choosing localities from which specimens should be taken from large masses of material. (Abstract.) Address before German Assn. for Testing Eng. Matls.

Methods. Report of Committee E-1 on Methods of Testing. Am. Soc. Testing Matls.—Preprint no. 3, for mtg. June 21, 1926, 58 pp., 34 figs. Reports of sub-committee on mechanical and impact testing; volatility, plasticity and consistency, determination of water, shape and size and methods for density; report on testing of thin sheet metals; facilities and methods for making impact tests and their interpretation; proposed methods of impact testing.

TEXTILE MILLS

Locating Hidden Wastes. Mechanical and Material Research in Management, T. P. Gates. Mech. Eng., vol. 48, no. 6, June 1926, pp. 579–582, 5 figs. Method for locating hidden wastes in textile manufacturing that has shown marked results, and its application in mercerizing problem.

TEXTILES

Testing. Report of Committee D-13 on Textile Materials. Am. Soc. Testing Matls.—Preprint no. 77, for mtg. June 21, 1926, 19 pp., 4 figs. Proposed general methods of testing textile fabrics; specifications for tolerances and test methods for rayon, and for electrical cotton tapes.

TIME STUDY

Steel Molding. Application of Time Studies to Steel Molding (Anwendung der Zeitstudien in der Stahlformerei), H. Resow. Stahl u. Eisen, vol. 46, no. 21, May 27, 1926, pp. 706–714, 12 figs. Aim and purpose of time studies; describes new and simple method of piece-work calculation for molding work.

TIRES, RUBBER

Balloon. Balloon Tires for Use with Drop-Center Rims, B. J. Lemon. Soc. Automotive Engrs.—Jl., vol. 18, no. 6, June 1926, pp. 623–630. British vs. American-made rims and tires; reintroduction of drop-center rims; British drop-center rim sizes; wheels and tires with drop-center rims; British medium-pressure tires, and tubes for drop-center rims; advantages and disadvantages from British viewpoint; drop-center tires and rims in America.

Tire Engineering Centers Around Bus Balloons, W. L. Carver. Automotive Industries, vol. 54, no. 23, June 10, 1926, pp. 982–986, 7 figs. Giant low-pressure tires regarded as partial remedy for troubles caused by heat from brakes; tire management and brake drum design also enter into problems of wear.

Sizes and Types. Sizes and Types of American Tires. India Rubber World, vol. 74, no. 2, May 1, 1926, pp. 74–76. Analysis of tire equipment for motor trucks, motor buses, passenger cars, electric trucks, taxicabs, and motorcycles.

TOOL STEEL

Selection. The Selection of Proper Material for Tool Manufacture, J. R. Mudge. Mech. Eng., vol. 48, no. 7, July 1926, pp. 727–730, 5 figs. Tool-steel specifications and selection of steel for tools.

TOOLS

Manufacture. The Division of Labor in Tool Manufacturing, G. A. Pennock. West. Soc. Engrs.—Jl., vol. 31, no. 3, Mar. 1926, pp. 97–102. Describes modern organization of specialists, each performing only part of operations in making tools; such system should obviously bring many economies and comparison of costs given by author reveals savings under newer order; these refer only to toolmaking expense.

TORSION

Twist Meter for Tests. A New Twist Meter for Torsion Tests, J. H. Smith. Am. Soc. Testing Matls.—Preprint no. 84, for mtg. June 21, 1926, 4 pp., 2 figs. New type of instrument for accurately measuring twist in torsion tests, designed in such manner as to be quickly attached to and removed from test specimens.

TRACTORS

Caterpillar. The Development of the Caterpillar Tractor and Its Application to Industry, P. E. Holt. Mech. Eng. (Supp.), vol. 48, no. 6, June 1926, pp. 657–661, 7 figs. Historical; inception of idea of endless-track principle and its development into workable machine; caterpillar in World War; standardization and refinement in manufacture; universal application to industry.

Farm. Tractor Lug Studies on Sandy Soil, J. W. Randolph. Agric. Eng., vol. 7, no. 5, May 1926, pp. 178–184, 8 figs. Studies have been under way at Alabama experiment station to determine laws governing traction of wheeled tractors; study of angle lugs with sandy soil under laboratory conditions.

Lubrication. Tractor Lubrication and Lubricants. Lubrication, vol. 12, no. 4, Apr. 1926, pp. 37–48, 19 figs. Relation of physical characteristics of tractor oils to operating conditions; tractor-engine oil requirements; mechanical conditions involved; transmissions, final drives and other gearing.

V

VALVES

Flow Resistance. The Flow Resistances of Modern Steam Stop Valves (Die Durchflusswiderstände neuerer Dampfabsperrorgane), K. Wetjen. Wärme, vol. 49, no. 15, Apr. 9, 1926, pp. 255–259, 9 figs. Comparative tests on standard stop valves of conventional design, Koswa valves of Schmidt design, and high-pressure valves; Koswa valves show considerably less flow resistance; high-pressure valves are almost resistance-free.

Pipe-Line. Valves for the Fourth Thirlmere Pipe Line. Engineer, vol. 141, no. 3672, May 28, 1926, pp. 550–552, 10 figs. Laying of fourth line completes aqueduct between Lake Thirlmere and Manchester; fourth line consists of 29 siphons having aggregate length of 32 mi. and are controlled by valves at each end; on longer siphons there are manual sluice valves, reflux valves, automatic stop valves and double-ball air valves; all of these appliances are described.

Relief. A High-Pressure Relief Valve, F. A. Ernst and F. C. Reed. Mech. Eng., vol. 48, no. 6, June 1926, pp. 595–597, 11 figs. Difficulties encountered with valves of commercial design; steps taken in evolving dependable design; details regarding materials and processes of manufacture.

VARNISHES

Aircraft. Pyroxylin Finishes for Aircraft, A. C. Zimmerman. Air Service Information Cir., vol. 6, no. 561, Mar. 15, 1926, 6 pp. Investigation of several commercial pyroxylin coatings to determine their suitability for use on wood and metal aircraft parts.

VISCOSIMETERS

Air-Bubble. The Air-Bubble Viscometer, G. Barr. Lond., Edinburgh & Dublin Philosophical Mag. & Jl. Sci., vol. 1, no. 2, Feb. 1926, pp. 395–405, 1 fig. Effects of length of bubble and diameter of tube have been examined and rate of rise determined for several oils of known viscosity and surface tension, for water and for glycerin in different tubes; above certain limit, length of bubble is without appreciable effect on rate of rise; air-bubble viscosimeter may be used with confidence for approximate comparison of viscosities of materials of same class.

W

WELDING

Boilers. Autogenously and Electrically Welded Boilers and Containers, E. Hohn. Mech. Eng., vol. 48, no. 6, June 1926, pp. 603–609, 71 figs. Results of investigation of strength and tenacity of parts welded together; there are now no further obstacles in way of employing such welded joints; for example, flanges welded on are stronger than those screwed on or rolled on and rings welded on stiffen manhole walls much better than do those riveted on; author proposes new method of safeguarding welded seams by means of straps welded on, and gives examples of welded boilers, compressed-air receivers and other types of pressure vessels. Translated from Zeit. des Vereines deutscher Ingenieure, Jan. 23 and Feb. 6, 1926.

Electric. See ELECTRICAL WELDING, ARC.

Methods. Economic Development of Welding and Cutting Industry (Anregungen für die wirtschaftliche Weiterentwicklung der Schweiss- und Schmeidindustrie), A. Krebs. Maschinenbau, vol. 5, no. 8, Apr. 15, 1926, pp. 369–370. Discusses shortcomings of oxyacetylene and electric welding; electrolytic action of arc, proper pressure of cylinder gases; weakness of spot welding, etc.

Oxyacetylene. See OXYACETYLENE WELDING.

Pipe. Pipe Welding Proves Economical, H. A. Woodworth. Power Plant Eng., vol. 30, no. 12, June 15, 1926, pp. 706–708, 5 figs. Study of steel-pipe welding resulted in finding that steel has high melting point and is difficult to weld; brass and bronze are not satisfactory at temperatures above 600 deg.; kind of welding rod to use; estimated cost of welding extra heavy type.

Rods. Effect of Surface on Steel Electrodes, J. B. Green. Welding Engr., vol. 2, no. 6, June 1926, pp. 38–40. Effect of surface materials on both gas and electric filler rods seems to be fully as great as effect of chemical analysis, especially in electric welding.

WELDS

X-Ray Tests. X-Ray Tests of Welds Reveal Some Defects, but Not All. Power, vol. 63, no. 21, May 25, 1926, pp. 800–803, 12 figs. Investigation indicates that X-ray examination of fusion-welded joints is of value in revealing certain types of defects, particularly voids and oxide inclusions; X-ray missed defects due to insufficient fusion.

WINDING ENGINES

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